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Economic Valuation of Bhoj Wetlands for Sustainable Use

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ECONOMIC VALUATION OF BHOJ WETLAND FOR SUSTAINABLE USE

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With the research support of

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Cover Page- Bhoj Wetland in a cloudy Day with Takia Island in backdrop.
Back Page – Upper Lake at sunset
Courtesy Central Colour Lab, Bhopal.

Black & White Photo- The magnificent Upper Lake with the then amazing Yacht Club –

Captured in Camera in 1961

Courtesy Mr. Prem Verma, Bhopal

PREFACE

Wetlands are the resources that interface between land & water systems. They are amongst the most productive & biologically rich ecosystems and are also amongst the most endangered. Wetlands include lakes, ponds, mangroves, swamps, marshes and coral reefs. Wetlands are complex ecosystems that are responsible for providing a wide array of unmeasured goods and services that benefit people. The livelihoods of millions of people in India are also dependent on these ecosystems. Despite all these benefits from the wetlands they have been mismanaged and are often neglected. Many decision-makers and even so called stakeholders think of wetlands as 'wastelands'. These so-called wastelands are continued to be drained, depleted at an alarming rate through conversion to what some would term as 'better' alternate use like agriculture, industrial activity and residential housing development. At many a places they have been converted into a cesspool as they are considered as 'most accessible sink' for throwing various wastes.

Wetlands, like many other common property resources are openly accessible to all. Every one claims a stake in their use, but few are willing to pay for the extractive use. In India many wetlands are in urban areas such as in Bhopal, Hyderabad, Srinagar, Udaipur, Nainital, Ooty, Thane. These urban wetlands are constantly degrading on account of various anthropogenic activities like urban development, encroachment, flow of domestic sewage, pesticides, fertilizers and industrial effluents, over fishing, boating, infestation with aquatic weeds and eutrophication, disturbances from excessive recreational activities and tourism, diversion of water from irrigation, domestic use or industrial uses.

In many cities like Bhopal wetlands originated as manmade lakes primarily to supply drinking water to the city's population and over the years they attained features of wetland and started providing multiple functions like commercial fishing, recreation etc. It has so happened that multiple benefits are extracted but little attention has been paid on the maintenance of these wetlands. ***In this context it becomes imperative to generate quantitative information on the economic benefits from wetlands, which could serve as a powerful tool to influence decision-making***.

There is need to develop a comprehensive framework to implement a long-term programme for wetland valuation and policy responses.

The Bhoj Wetland located in the heart of the city of Bhopal is one of the 16 wetlands of National Importance in the country. It is unique in its own way since it is an ancient man-made reservoir and provides drinking water to nearly 45 per cent of the city's population of 15,00,000. It also provides a number of other direct and indirect benefits to the population living in the city. The growing population pressures and human interference have led to degradation of this Wetland. There are numerous threats, which face this fragile urban ecosystem and threaten its very existence in fact.

The current research project '"Economic Valuation of Bhoj Wetland for Sustainable Use" attempts to analyse the factors causing Bhoj Wetland degradation; nature and extent of injury to the wetland; How does this degradation impact on the uses that citizens of Bhopal extract out of it ? What cost is borne by the users on account of degradation in terms of productivity losses and health impacts? How feedback can be taken from these impacts to revise or develop management policies and to seek participation of stakeholders to check wetland degradation or losses? What is the willingness of the people to pay to conserve this wetland?

It was realised that economic valuation need to be attempted to make people aware of the worth of various benefits as well as losses from the wetland and valuation results so obtain could be used to counter wetland degradation. It is high time that necessary steps should be taken both in terms of physical interventions (prevention and restoration activities) and economic instruments such that stream of benefits from Bhoj wetland continue to be available in future as well.

Though the urban wetlands are mandated under the Indian Constitution to be maintain by the Municipality but there is an urgent need to involve various stakeholders and resort to 'collaborative or integrated management' and 'sustainable and equitable use'.

Plan of Study

The report is divided into two parts. The first two chapters of Part I provide an account of the functions & values of wetlands (Chapter I); techniques of valuing natural resources and wetlands in particular (Chapter II). Part II begins with highlighting the importance of water resources and introduces the study area i.e. the Bhoj Wetalnd, its features, user & threats and elaborates the objectives (Chapter III); the report then discusses the project methodology and particularly valuation techniques applicable to wetland valuation (Chapter IV); ecosystem modelling of Bhoj Wetland using water quality parameters to project future scenarios and matching policy interventions (Chapter V); use values generated through direct and indirect valuation approaches (Chapter VI); and recommends strategies for sustainable management. The annexures at the end of the report contains ward wise population of Bhopal city (Annexure I); questionnaire used for conduction of CVM & Hedonic Pricing surveys (Annexure II); details of stakeholders workshop seeking their perceptions on management issues of Bhoj Wetland (Annexure III).

Acknowledgements

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I wish to also thank EERC for continuously providing us with the comments of various experts and timely availability of financial assistance to smoothly carryout our research work. My deep appreciation to all those authors whose writings are quoted in the report which made my team understand wetlands problems and valuation techniques.

I have been specially influenced by the work of Dr. Gopal K. Kadekodi & Dr. S. C Gulati on “Root Causes of Biodiversity Losses in Chilika Lake: Reflections on Socio Economic Magnitudes” which greatly helped us in analysing wetland management issues and developing our System’s Dynamics model for the Bhoj wetland. I am specially indebted to Dr. Gopal K. Kadekodi (Research professor, CMDR, Dharwad) who was retained as a consultant in the project & who immensely helped us in the developing the ecological model using STELLA software. I am also thankful to him for allowing my team to make use of DEFINITE software at CMDR, Dharwad for Multri Criteria Analysis for property valuation. I am also thankful to Ms. Aparna Nayampalli (Research Associate, CMDR, Dharwad) for helping us throughout in model calibration and validation. I wish to extend my heart felt thanks to Dr. A.J.James, (Environmental Consultant,New Delhi) for extending great help to us in learning and administering CVM in our survey and his valuable input in stakeholders workshop and supplying great deal of literature. I am grateful to Dr. David Simpson (Natural Resource Economist, Resources for Future, Washington, USA) for giving his valuable time to come down to Bhopal and for his input for helping us to make use of Hedonic Pricing technique of valuation. I also express my gratitude to Dr. Kanchan Chopra (Prof. IEG, Delhi) for her guidance and comments throughout the project. Dr. T. R. Manoharan (Research Associate, RIS. New Delhi) deserves thanks for extending literature support and comments. I am thankful to Dr. C.L.Trisal

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Two workshops were conducted during the project with the stakeholders, Corporators and concerned line department officials to seek their perception on the management issues of the Bhoj Wetland. I wish to acknowledge the support of Smt. Vibha Patel (Mayor-in-Council, Bhopal City), Dr. Satyanand Mishra (Principal Secretary, Housing and Environment, Govt. of M.P.), Dr. D.P.Tiwari (Commissioner, BMC), Dr. G.K.Vyas (Health Officer), Shri Majid Khan(City Engineer, PHED), Corporators of various wards of Bhopal Municipal Corporation, representatives from washermen, fishermen communities, experts from Limnology Department, Barkatullah University, Shri Abdul Jabbar (Gas Peedit Mahila Morcha, Bhopal), Shri Satisnath Sarangi (Sadbhawna Trust, Bhopal) and other representatives from various NGOs for actively participating in the workshop and helping us to extract major threats and the management issues. I am thankful to media persons for giving coverage to the workshop deliberations as well as about our overall project in news papers, television and radio.

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During the length of the project the team at IIFM had the opportunity to interact a large number of experts during the midterm review workshop of the first phase EERC projects in Bangalore (December,1999). This workshop provided very useful inputs to shape up our study in more focused manner. While carrying out the project work, I got an opportunity to attend the “International Symposium on Transdiciplinary Approaches” to Ecosystem Health organised by International Society for Ecosystem Health at Brisbane, Australia (July, 2000) and to make a presentation regarding our project work. I received comments of many international experts which greatly helped in making effective use of the information collected during the project. I am deeply indebted to Mr.Delmar Blasco (the Secretary General) & Mr. Dewight Peck, (Executive Assistant for Communication) of the Ramsar Bureau, Glad, Switzerland for sponsoring my within Australia trip to attend this conference and also putting a news item pertaining to the presentation on the Ramsar website (August 2000 News Bulletin). While completing this project I also had on opportunity to attend the “Beijer Research Seminar on Environmental Economics” at Dhulikhel, Nepal sponsored & organised by the Beijer Institute, Stockholm, Sweden and to present our paper on “Total Economic Valuation of Bhoj Wetland for Sustainable Use”. I wish to acknowledge the valuable comments of Dr. Karl-Goran Mailer (Beijer Institute, Stockholm, Sweden), Dr. Partha Das Gupta (Cambridge University, Cambridge, U.K.), Dr. Jeffery Vincent (Harvard Institute of International Development, Boston, USA), Dr. Sara Aniyer (Beijer Institute, Stockholm, Sweden), Dr. Priya Shyam Sunder(World Bank, Washington, USA) and members from academic institutions of India, Pakistan, Bangladesh, Nepal & Srilanka who attended the seminar. We benefited immensely from the above mentioned workshops and the notions of value, analysis and interpretation that entered into this work stand testimony to this interaction.

Work of this proportion & diversity is not possible without constant support of committed researchers. I wish to put on record the untiring work and committed

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March 21, 2001 **Madhu Verma**

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The Magnificent Upper Lake with the then Amazing Yacht Club – Captured in Camera in 1961

Nature never gives anything to anyone; everything is sold. It is only in the abstraction of ideals that choice comes without consequence.

- ***Ralph Waldo Emerson***

CHAPTER I : WETLANDS: FUNCTIONS AND VALUES

1.1 Definition

Wetlands are ubiquitous and can be found in all regions and climates. The term 'Wetland' came into use in 1970s and was soon generally accepted. Wetlands may be defined as habitats were the water table is situated at or near the ground surface, bearing vegetation adapted to more or less continuous water logging. Wetlands form a buffer between waterways and commercial, residential and agricultural lands. They are complex natural processes and contribute to overall order and stability of the ecosystem.

The Ramsar Convention defines wetlands as: ***"Areas of marsh, fen, peatland, or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, depth of which at low tide does not exceed six meters"*** and may include *"riparian and coastal zones adjacent to the wetlands or islands or bodies of marine water deeper than six meters at low tide lying within".* (IUCN1971)

Wetlands occupy an estimated 6 per cent of the world's land surface (Mitch and Gosselink,1993). Tropical wetlands, in particular are on the whole poorly understood and yet collectively they represent some of the most important areas of the World's wetlands. Coupling of sound management policy to the scientific understanding of how wetlands work and what goods they provide and services they perform is essential if rapidly diminishing ecosystems are to be maintained for the future.

Wetlands are very important ecosystems, providing human societies with essential and highly valuable life supporting functions (Odum, 1989). Monetary valuation of wetlands have usually concentrated on specific environmental services such as water supply, flood prevention, pollution reduction, fish and wild life production, the provision of recreation and aesthetics [Hammack & Brown 1974; Lynn et al.,1981; Faber,1987] Less frequently, attempts have been made to estimate the life support value of entire wetland ecosystems which are generally required to sustain each environmental service.[Odum1984; Costanza et al.,1989]

1.2 Wetland Classification

Wetlands vary according to their origin, geographical location, water regime, chemistry, dominant plants and soil or sediment characteristics. Tidal salt-marshes are typical of temperate shorelines. Freshwater marshes, dominated by grasses and sedges, account for over 90 per cent of the wetland area in the United States.

The most commonly accepted classification of wetlands is the one proposed by IUCN, in 1990. This classification is as follows:

1.0 Salt water

1.1 Marine

I. Subtidal

(i) permanent unvegetated shallow waters less than 6m depth at low tide. Includes sea bays, straits

(ii) subtidal aquatic vegetation, including kelp beds, sea grasses, tropical marine meadows

(iii) coral reefs

II. Intertidal

(i) rocky marine shores, including cliffs and rocky shores

(ii) shores of mobile stones and shingle

(iii) intertidal mobile unvegetated mud, sand or saltflat

(iv) intertidal vegetated sediments, including salt marshes and mangroves on sheltered coasts

1.2 Estuarine

I. Subtidal

(i) estuarine waters: permanent waters of estuaries and estuarine systems of deltas.

II. Intertidal

(i) intertidal mud, sand or salt flat, with limited vegetation

(ii) intertidal marshes, including salt marshes, salt meadows, saltings, raised

salt marshes, tidal brackish and freshwater marshes

(iii) intertidal forested wetlands, including mangrove swamp, nipa swamp, tidal fresh water swamp forest

1.3 Lagoonar

(i) brackish to saline lagoons with one or more relatively narrow connections with the sea

1.4 Salt lake

(i) permanent and seasonal, brackish, saline or alkaline lakes, flats and marshes.

2.0 Fresh water

2.1 Riverine

I. Perennial

(i) permanent rivers and streams, including water falls

(ii) inland deltas

II. Temporary

(i) seasonal and irregular rivers and streams

(ii) riverine floodplains, including river flats, flooded river basins seasonally flooded grasslands

2.2 Lacustrine

I. Permanent

(i) permanent fresh water lakes (>8 ha), including shores subject to seasonal or irregular inundation

(ii) permanent fresh water ponds(>8 ha)

II. Seasonal

(i) seasonal fresh water lakes (>8 ha), including flood plain lakes

2.3 Palustrine

I. *Emergent*

(i) permanent freshwater marshes and swamps on inorganic soils, with emergent vegetation whose bases lie below the water table for atleast most of the growing season

(ii) permanent peat-forming fresh water swamps, including tropical upland valley swamps dominated by *Papyrus* or *Typha*

(iii) seasonal freshwater marshes on inorganic soil, including sloughs potholes, seasonally flooded meadows, sedge marshes and dambos

(iv) peatlands, including acidophilous, ombrogenous, or soligenous mires covered by moss, herbs or dwarf shrub vegetation and fens of all types

(v) alpine and polar wetlands, including seasonally flooded meadows moistened by temporary waters from snowmelt

(vi) freshwater springs and oases with surrounding vegetation

(vii) volcanic fumaroles continually moistened by emerging and condensing water vapour.

II. *Forested*

(i) shrub swamps, including shrub dominated fresh water marsh

(ii) fresh water swamp forest, including seasonally flooded forest, wooded swamps on inorganic soils

(iii) forested peatlands, including peat swamp forest

3.0 Man-made wetlands

3.1 Aquaculture/mariculture

(i) aquatic ponds, including fish ponds and shrimp ponds

3.2 Agriculture

(i) ponds including farm ponds, stock ponds, small tanks

(ii) irrigated land and irrigation channels, including rice fields, canals and ditches

(iii) seasonally flooded arable land

3.3 Salt Exploitation

(i) salt pans and salines

3.4 Urban/ industrial

(i) excavations, including gravel pits, barrow pits and mining pools

(ii) waste water treatment areas, including sewage farms, settling ponds and
oxidation basins

3.5 Water Storage Areas

(i) reservoirs holding water for irrigation and /or human consumption with a pattern of gradual, seasonal, draw down of water level

(ii) hydro dams with regular fluctuation in water levels on a weekly or monthly basis

Source: Dugan (1990 a). (c) IUCN

1.3 Wetland Benefits

Wetlands are generally highly productive ecosystems, providing many important benefits. These benefits some times described as 'goods and services', may be wetland functions (e.g. ground water recharge, flood control), uses of wetland or its products (e.g. site for wood collection or research site) or attributes of the wetland (aesthetic component of the landscape, religious significance). In order to utilise the benefits provided by wetlands successfully it is important to identify and assess the benefits that a particular wetland provides.

Plate 1.1: Panoramic View of Upper Lake of Bhoi Wet Land

Table 1.1 Potential Wetland Benefits- Existence Indicators:

Benefit	Existence indicators
I. RESOURCES	
Forestry, agriculture, forage production	Wetland • has suitable plant species • has high rate of plant primary productivity • shows evidence of use
Wild life or fish production	Wetland • contains habitat suitable for wild life and fish species • has a variety of water conditions and vegetation structures • has a large population of fish, bird and mammals
Aquaculture	Wetland • has a relatively stable water table • has a relatively stable water quality • has high plant productivity • has nutrient rich waters • shows evidence of this use
Natural products	Wetland • has suitable, accessible mineral deposits • has extractable plant material that can be used by human beings (food, fertilizer etc.)
Water supply	Wetland • is permanent or at least seasonally flooded • has water of an acceptable quality for human or agriculture or industrial use • is the only supply of readily obtainable water of quality and quantity acceptable to the potential users
Energy production	Wetland • has resources such as peat or fuel wood or suitable plants • has a large through flow and a constricted outlet
Transport	Wetland • is permanently flooded or has permanent channels • is flooded or has flooded channels when local products needed to be transported
Recreation/ tourism	Wetland • has a high landscape or species diversity • provides habitats to rare species
Research or education site	Wetland • has high species diversity • has a range of vegetation structure

Benefit	Existence indicators
II. ATTRIBUTES	
Biological diversity	Wetland • has a high species diversity • has a diversity of water conditions and vegetation structures • is relatively undamaged/ undisturbed • is not facing uncontrollable external threats • contain rare, threatened or endangered species • is sufficiently large to support genetically viable populations of significant species • has a significant topographic, edaphic and hydrological variation
Cultural or historic value	Wetland • is included in local oral or written cultural materials • has been occupied and used over a long period • has significant cultural or historical features
Aesthetic value	Wetland • has significant natural features • has a range of landscape types • has a range of habitats • has a large number of visible or attractive species
Wilderness value	Wetland • is in a remote area • is relatively uninfluenced by human activities • is not subject to significant levels of visitation
III. FUNCTIONS	
Nutrient retention	Wetland • has a high capacity for sediment retention • has a constricted flow • has an out flow less than its inflow • has erect, persistent vegetation • has winding channels • has low flow velocity • has relatively long duration and large extent of seasonal flooding • has a high ratio of seasonally flooded area to permanently flooded area • has the effect of slowing the velocity of through flowing water • intercepts over land run – off • is regularly flooded by a river • is shallow and vegetative • is permanently flooded or saturated, or tidally flooded

Benefit	Existence indicators
	• has a high sediment organic content • has high plant species diversity with no dead forested area
Nutrient Export	Wetland • has a high rate of primary productivity • has a permanent outlet • is potentially eutrophic • has significant area of erect or submerged vegetation that dies seasonally
Ground Water Recharge	Wetland • has a constricted outflow • has an outflow less than its inflow • has a water table which slopes away from it • has a permanent inlet but no permanent outlet • has a permeable substrate • is located at or below the crest of a major mountain or range • has a water balance in which infiltration rate plus inflow exceeds evapo-transpiration rate plus outflow
Ground Water Discharge	Wetland • has a constricted inflow • has an outflow less than its inflow • has neither an outlet nor an inlet • does not have permanent standing water • has a permeable substrate • has a slope less than that of nearby water courses
Erosion Control	Wetland • has a high capacity of flood mitigation • is densely vegetated • has a high capacity for sediment retention
Salinity Control	Wetland • is seasonally flooded • has plant communities that are able to remove salts
Water Treatment (Toxicant Removal)	Wetland • has a high capacity for sediment retention • has a constricted outflow • has erect persistent vegetation • has winding channels • has no flow or low flow velocity • has relatively long duration and large extent of seasonal flooding

Benefit	Existence indicators
	• has a high ratio of seasonally flooded area to permanently flooded area • intercepts over land run-off • is shallow and vegetated
Climate Stabilisation	Wetland • has a high evapo-transpiration potential • has large vegetated area that provide shadow and reduce velocity of air movements • condense accumulated peat
Role in the Life Cycle of Species	Wetland • has a high plant species diversity • has a range of different vegetation structures • has a diversity of water conditions • is relatively rich in habitats, water and feed when conditions are unfavourable to fish, bird and mammal species elsewhere • is relatively undisturbed
Maintenance of the Stability of the Ecosystem	Wetland • has a high capacity for nutrient retention • has a high rate of primary productivity • has a relatively undisturbed trophic change • is rather stable in terms of plants and wildlife populations
Maintenance of the Integrity of Other Ecosystems	Wetland • regulates flows and mitigates floods • regulates water salinity • removes toxicants • regulates sediments exports • exports nutrients • provides seasonally/temporary habitats to migratory species • shows evidence of continuing ecologically, geomorphological and geological processes

Source: **Roggeri (Undated)**

1.4 Wetland Management

Despite the importance and potential of wetlands, the history of water management has been characterised by activities that have often negatively impacted wetlands and their ability to provide important benefits. Over the last few decades, as the scale of human interventions within river basins has increased so have the magnitudes of their effects upon wetlands. Many wetlands have been lost completely

whilst the ability of many of those that remain to provide valuable benefits has been reduced significantly. For example, Thailand has lost 51% of its mangrove whilst 20-30 million ha peat swamp forest in Indonesia has been lost through logging. (Trishal, 1997)

Fifty four percent of the wetland area of the coterminous United States present in colonial times had been lost by mid 1970s. Regional losses detailed in the benchmark survey, carried out as part of the US Fish and Wildlife's National Wetland Inventory vary from 32 per cent in Wisconsin to 99 per cent in Iowa's natural marshes. The pattern is repeated throughout the developed world, although there has been no comprehensive survey of the details, Forty per cent of the coastal wetlands of Brittany, France, have disappeared in the last 20 years and two-thirds of the remainder are seriously affected by drainage and other activities (Mermet cited by Baldock, 1984). In Ireland 80,000 ha of bog have been drained since 1946. A 1983 European parliament report warned that the unique ecosystems of the Irish bogs will vanish completely in the next five years unless effective preventative measures are taken very soon (Baldock, 1984). But already before the present century much of Europe's lowland wetlands had been drained in the course of agricultural development and disease eradication.

Large scale wetland losses have been a more recent phenomenon in the tropics and third world countries. Many reasons can be cited why, historically, wetland destruction and alteration has dominated over an alternative view of maintaining them and developing management strategies for their enhanced utilization. They include:

(a) Prevalence of the 'wasteland' concept - the view that drainage and conversion to other uses is a 'public-spirited endeavor' (Baldock 1984), resulting in increased productivity, value or access to land. Agricultural conversion has accounted for 87 per cent of wetland losses in the United States.

(b) Association of wetlands with disease particularly malaria and schistomiasis and physical danger in traversing such areas. This was one of the motives for draining the 6000 ha Hula Papyrus swamp in northern Israel in 1950s.

(c) The obvious flooding hazard associated with occupation or use of such land - periodic extreme events exerts pressures for protection thereby reducing the natural flooding regions. Progressive drainage of the English Fens was encouraged by public and political response to successive major flood events.

(d) Lack of government interest. Politicians are rarely taken up by the subject of wetlands and they rarely admit to responsibility beyond their own administrative or national boundaries which wetland issues demand. Control over wetlands also exposes in democratic communities tantalizing questions of rural land use, ownership restrictions, state control and inevitable conflicts of interest on the part of government.

(e) Lack of financial support for wetland protection and management. This is particularly acute in Third World Countries.

(f) Lack of any individual scientific identity or a cohesive form of academic study centered on wetland per se. This has delayed the dissemination of fundamental and management information pertaining to wetland.

Sustainable use of wetlands is being threatened around the globe, both in the North and in the South. Humanity depends on all sizes and kind of wetlands - natural or artificial, ephemeral or permanent - for drinking water, food supply, power production, navigation, ecological services, and economic development. Moreover, wetlands are integrators of the many complex chemical, physical and biological processes occurring throughout entire watersheds. They serve as indicators of adverse environmental change.

It is clear that an economic analysis of beneficial uses associated with wetlands should be comprehensive, dynamic and include all potential uses and users since they affect each other. A special feature is the dynamic aspect of wetland ecosystem degradation. The capacity of different types of wetlands to sustain levels of pollution varies and is limited. In many cases, the damage to wetland ecosystems, especially the biological communities, is irreversible. This means that benefits to local populations that depend on wetlands are foregone. The poor may lose their source of nutrition, and others may lose their source of employment and may migrate. Furthermore, investments may be wasted. Many wetlands in the world are

approaching limits or thresholds where their sustainability and beneficial uses will be severely diminished or lost. Corrective actions or costly remedies may be necessary if mismanagement and misuse of wetlands and watersheds continue unchecked. (Ariel et.al, 1995)

1.5 Quantification of Wetland Benefits

It is necessary to quantify the benefits provided by wetlands as far as possible if effective choices are to be made between development and management options. Planners, decision makers and politicians are greatly influenced by economic issues. Demonstrating the economic value of the benefits provided by wetlands there for provides one of the most important mechanism for showing that they should be formally incorporated into wetland management. It is important that the emphasis of such economic analysis is not placed solely on those values that are more easily quantified on economic grounds. In order to represent the true value of a wetland attempts must be made to evaluate all benefits that they provide

1.6 Threats to Wetlands

Over the last 50 years, the world population has almost tripled. Most of this increase has occurred in developing countries. The use of water during the same period has more than tripled. The exploitation of lands, bodies of water, and forests resulting from development has increased dramatically. This has led to a number of pronounced problems in wetlands. Changes in the natural landscape from resource extraction, introduction of new and more intensive types of agricultural practices, urbanisation, altered water balances, and hydrological regimes have all influenced the state of wetlands around the world.

Wetlands have a more complex and fragile ecosystem than rivers. They do not have a “self cleaning” ability, and therefore they readily accumulate pollution. Because of their importance their beauty, their religious and cultural significance, and their relative vulnerability to degradation, wetlands require more concerted attention than is applied generally to river and stream basins. Although pollution of other waterways is also a pressing issue, the unique features and situation of wetlands makes it important to deal with them first.

Various ecological problems occur in wetlands such as eutrophication, toxic contamination accelerated sedimentation, acidification from atmospheric deposition excessive water diversion, fish depletion, introduction of exotic species, and habitat alteration. A brief description of some of these ecological problems is provided below to demonstrate their variety, complexity and geographical breadth.

a) Eutrophication

One of the most visible and common problems of wetland ecosystems is accelerated enrichment or eutrophication. Eutrophication of a water body is a natural process. The original state of a wetland and the rate at which at which eutrophication takes place depends on the location of the water body, its hydraulic character, and the attributes of its watershed including soils, slopes of terrain, and extent of vegetative cover. Wetlands can be rather unproductive (oligotrophic), or highly enriched (hypereutrophic), or various degrees in between. Most wetlands are eutrophic.

The effects of accelerated eutrophication can include intensified algal blooms, which can create unsightly water conditions, unpleasant tastes and odours, and water discoloration. Some of the algae (the blue-greens) can produce toxins that are lethal to domestic animals and in temperate regions, and may be linked to certain summer illness in humans (USEPA 1988). Eutrophic conditions also contribute to the potential presence of toxic and harmful materials such as chlorinated organic hydrocarbons (e.g. trihalomethanes) in drinking water, which may persist even after water treatment. When algae die and decompose, dissolved oxygen concentrations in the bottom water can be depleted to the point of causing severe stress on fish. If the situation continues or intensifies, the result could be changes in species composition, growth reductions, and under certain conditions, extensive fish death.

Macrophyte (rooted and floating aquatic plants) abundance, while partly related to sediment type or composition, and to nutrient factors, is most often determined by light availability. It is a common misconception that nutrient enrichment causes nuisance macrophyte growth. In fact, high nutrient concentrations in the water column trigger algal blooms decreasing light

penetration, and limiting macrophyte growth (Cooke et. al. 1993). Clear wetlands with nutrient- rich littoral areas can display excessive macrophyte growth, which is very noticeable in Lake Chad and is apparent in Lake Victoria with abundant growth of water hyacinths. Macrophyte beds are important features of lakes. They are essential as spawning areas for fish and shellfish, and provide refuge against predator species for some fish. They can provide important societal benefits as well, as in the case of Lake Titicaca, where certain species of macrophytes are used for nutrition and provide materials for construction.

Macrophyte beds become a problem when they cover large areas of a wetland surface. Excessive growth can impede boat traffic, create dangerous areas to fisherman and swimmers, and can increase the cost of water treatment if plants break off and are transported to treatment facilities (where they can clog water intakes). The danger of introduced plants species (mostly unintentionally) is also a threat to wetland sustainability. The invasion of North American waterweeds (*Elodea* spp.) into other parts of the world is a well-known example. The distribution of *E. canadensis* is now almost world-wide and *E. nuttallii* seems to follow a similar track, invading Europe and Japan. Some lake ecosystems, for example those on oceanic islands, consist of a limited variety of flora and fauna and are less resistant to invader species.

b) Toxic substances

In 1982, over 275 million tons of hazardous waste were produced by industry in 13 of the 23 Organisation for Economic Co-operation and Development (OECD) countries that reported on waste disposal (Rogers et. al. 1988). It is also estimated that 1.3 million metric tons of pesticides were used in the world in 1985. Although the amount of these substances that reach lakes and reservoirs is unclear, the sheer size of the number indicates the potential for lake and reservoir pollution is very large. There is strong indication that a growth in hazardous waste production can be expected with increased industrialisation and with production and use of synthetic organic compounds. Much of this expansion is to be expected in developing countries and more lakes and reservoirs will become contaminated. This potential growth in the

production of hazardous waste was confirmed by the World Bank in 1969. Thailand had only 500 factories producing hazardous waste, by 1992 that number grew to more than 26,000 factories, and it could triple in one more decade (World Bank 1992).

Toxic substances can enter water bodies directly as land runoff from urban streets, mining areas or as agricultural runoff including forestry drainage frequently including a range of toxic pesticides and herbicides, or by the discharge of insufficiently treated sewage and industrial effluents, and as deposition of airborne pollutants. Airborne transport is particularly troublesome since sources can be at great distances as indicated for the Great Lakes. In the case of Lake Michigan the atmosphere is the main source of lead, zinc, copper, and cadmium. Toxins can also be created in drinking water to form cancer-causing compounds such as trihalomethanes (THMs).

c) Sedimentation

Sedimentation of wetlands is a normal occurrence. In general, it takes place very slowly. However, activities in a wetland's watershed that disturb the soil can greatly accelerate this process. Most of these activities are human and include farming on fragile soil and on steep slopes, surface mining, forestry, construction activities, and urban drainage from streets and pavements.

Suspended sediment and sedimentation have many degrading effects on wetland and shoreline ecosystems. Marginal wetlands can be completely covered by silt, eliminating their value as nutrient sinks, wave absorber, nursery areas, and habitat. As silt settles in a lake, spawning areas are covered and lake volume is reduced. A complete change in fishery production can occur. As a result of lost storage capacity, both the volume and extent of flooding can increase. In the case of hydro-electric facilities, loss of generating capacity is possible. The increase in shallow areas as a result of sedimentation can encourage increased macrophyte growth, and can interfere with recreational activities such as boating and fishing. Soil loss and suspended silt also contributes to eutrophication and lake contamination since the silt generally includes attached nutrients, herbicides, pesticides and other

chemicals. This increases water treatment and maintenance problems in water treatment plants.

Sediment removal might be the only practical way to improve a lake or reservoir that has been badly silted. Dredging is one of the most frequently prescribed techniques to correct this problem. It has been successfully used in Lake Trummen, a small lake in southern Sweden, and in Lake Vancouver in the United States. Dredging, however, is costly (for example, Hitzhusen et al., (1995) estimated the dredging cost in Lake Madison in Ohio to be $1.65 per ton of sediments dredged) and works best if the sources of sediment delivery are first controlled, eliminating the need for re-dredging. Because dredging requires the disturbance of the lake bottom, any entrapped toxic materials in the bottom sediment can be re-suspended and made available to the biological community in the lake.

d) Fish depletion

Fish provide a large percent of animal protein consumed by the world population. In tropical developing countries, 60 percent of the people depend on fish for 40 percent or more of their protein (WRI, 1994). The majority of the world's landed fish catch (87 percent) comes from marine areas. Of this, the annual freshwater catch grew 85 per cent between the late 1970s and the late 1980s, while the annual marine catch may have reached a limit near 100 million metric tons and more pressure on freshwater fisheries may result. This could mean that lakes and reservoirs, as sources of fish protein will become more important.

In eutrophic conditions, either natural or induced by heavy inflows of sewerage or agricultural run-off, a high biomass is likely to be found. A positive correlation between fish yields and total production of algae has been reported in some cases, and in other cases there is a positive correlation between fish production and bottom dwelling invertebrates (Hecky et al., 1981). The same increase in nutrients may promote intense algal blooms, however, leading to increased biological oxygen demand, oxygen depletion in bottom water and a change in the fishery.

When non-native exotic fish have been increased, intentionally or by accident, changes in biomass, species composition, and production may occur. Although total fish production might remain the same or even increase, the change in species composition might disrupt the livelihood of local human populations, and can affect the biodiversity in the wetland. An example of effects of this kind is the introduction of the species perjury into Lake Titicaca, where this very hardy pollution-tolerant fish appears to be thriving as the lake waters are becoming more eutrophic and polluted with human wastes and pathogens. Indigenous people, with little choice, are exposed to great health risks from eating the contaminated fish.

e) Excessive Water Diversion

Water diversion or its disruption probably has the greatest effect on the overall quality and ecological health of a lake or reservoir ecosystem. Diversion of water out of a lake system, frequently tied to non-sustainable economic development schemes, are used for supplying irrigation water, drinking water, or industrial process water to other regions that lack water. Dramatic examples of the adverse effect of diversion include the Aral Sea. Mono Lake, and in the Lake Chad basin. In the case of the Aral Sea, more than 60 percent of the incoming flow to the lake was diverted for irrigating cotton and other agricultural crops (Precoda, 1991). Consequently, the surface area of the lake was reduced by 5 percent to 37,000 square kilometres (Km^2), its volume was reduced from 1090 Km^3 to 340 Km^3, and its salinity has almost tripled.(World Bank,1992and Micklin,1992)

Diversion has other consequences. Raising and lowering of lake levels destroys marginal habitat and wetland areas, that are necessary for nursery grounds for terrestrial and aquatic species, buffer zones to erosive wave action, water recharge, and nutrient sinks. Lake lowering increases difficulty in water access, disrupts water intakes, erodes embankments and disturbs recreational use.

Across the world, transboundary water pollution and inappropriate water management practices interfere with society’s use of wetland water. While

almost 300 treaties exist for transboundary water management, most of them deal with the quality aspect of water use by sectors and do not concern them selves with pollution or ecosystem issues. The large African lakes, the Great Lakes of North America, small lakes in the deltas of international river basins of Africa, and lakes like Titicaca, Baikal, Constance, and Geneva all have drainage basins covering more than one nation.

In some cases, countries have taken action to reduce pollutant loading. Lake Vanern, Constance, Geneva, and the five North American Great Lakes are good examples of this. Pollution from man made toxic chemicals is particularly difficult to address not only because the source of pollution must be reduced, but accumulation of persistent toxins in the environment must be investigated and expensive remedial actions undertaken. Many areas of the great lakes have highly contaminated bottom sediments. This is true particularly in harbours and bays containing industrial sites, and in river deltas where upstream industry has discharged wastes containing toxins. The great lakes experience offers an example of international co-operation by two nations involving all stakeholders in the process of identifying the extent of the problem, understanding the health threats to the ecological system and the people of the basin, defining appropriate mitigation, including the institutional and technological requirements. Sediments from deforestation in Malawi, Tanzania and Mozambique inhibit fish production in Lake Malawi. In Lake Titicaca, eutrophication stimulates algae, which shade out aquatic plants that are essential to the ecosystem and to indigenous peoples. In Lake Victoria, the combined effects of overfishing, introduction of nonindigenous fish and aquatic weeds, and sewage pollution causes very complex degradation of the lake and problems for residents of the three riparian countries. In the case of lakes connected to oceans, accidental introduction of nonindigenous species in ballast water from ships causes extreme damage. The lake Erie aquatic ecosystem, which provides $200,000,000 in fishing benefits each year may soon collapse because of the Zebra mussels introduced via ballast water of ships from Europe. Billions of dollars need to be spent to prevent fouling of intake and discharge pipes clogged by the mussels.

Poor water management in terms of upstream diversion or changes in flow regimes downstream of reservoirs also degrades wetland ecosystems, causing economic damage, and human suffering. In case of delta wetlands in international river systems that are essential for fish propagation, upstream withdrawals of water cause salinity to increase and ruin the functioning of the wetlands. Impoundments for hydropower also prevent annual floods that are essential for floodplain wetlands, flood recession agriculture, and recharge of ground water supplies. This destroys the fishery of African rivers, displace floodplain peoples, and dries up their ground water supplies. Proper water management practices are needed to ensure that there is sufficient water left in international rivers to recharge delta wetlands and that reservoir releases include the provision of an annual downstream flood to enable flood plain lake ecosystem and flood plain agricultural communities to survive. Disruption of sediment flow to coastal zones by dam construction can cause coastal erosion, and in West Africa entire coastal towns have been washed away.

Two international issues also raise problems of wetlands. One involves a dynamic link between wetlands and ground water supplies and the other involves atmospheric deposition of wetlands. Lake Chad represents a good case of links between wetlands and underlying groundwater drinking supplies. As more water has been diverted for irrigation from the lake basin (and as climate became drier) the lake has shrunk, wetlands that sustained the lake fishery have dried up, and groundwater levels have declined. The international groundwater around this wetland is connected to the lake and depends on lake inflow to sustain its level. Too much diversion for agriculture also means that groundwater sources in this dry climate may not be sustained. (World Bank Technical Paper No. 289)

The South Asian region has a wealth of wetland habitats of immense importance in terms of ecology and economics. They exhibit enormous diversity based on their origin, geography, hydrological regime and substrate. The wetlands of South Asia have always provided human beings with basic necessities, from water for drinking to fertile soils for growing crops and other products for their sustenance. The people

have developed unique techniques for harnessing these resources without altering the ecological balance of the wetlands. However, with the advent of science and technology, which have led to the rapid utilisation of natural resources and favoured land based development, wetlands have been drained, filled and reclaimed for higher economic gains, particularly to grow more food for the increasing population. This has led to a considerable alteration of wetland habitats and reduction in their potential to provide ecological and economic security for the people dependent on their resources.

In South Asia wetlands have traditionally been utilized sustainably by a large population dependent on these resources for their sustenance. However with the increased pressures of human population and unplanned development in the region, wetlands are being destroyed at a rapid rate, resulting in a shrinkage in area and decline in productivity, and thus in their ability to meet the needs of the local people. This is particularly pronounced in the coastal areas, where indiscriminate use of resources and conversion for aquaculture and other development activities have resulted in the degradation of mangroves, seagrass beds and coral reefs. Similarly, the combined effect of degradation of inland wetlands have led to problems of siltation, loss of biodiversity and the prolific growth of exotic aquatic weeds such as water hyacinth (Trisal, 1997).

The weedy and marshy wetlands of low lying cities in South and Southeast Asia have variety of uses - as dumping ground of industrial effluents and urban refuge through default option, as highly attractive money making proposition to convert them into busy industrial complexes and /or civilised- looking housing conglomerates, or as financially less lucrative *albeit* environmentally sustainable option of converting them into smiling "nature parks". (Datta & Sinha,1996)

The low lying cities of Calcutta, Dhaka, Mumbai, Jakarta, Bangkok, etc. are well known for the traditional practice of dumping industrial effluent and urban refuge on their weedy and marshy wetlands for converting such wetlands into busy industrial and housing complexes under pressure of population growth and development.

Table 1.2: Selected Impacts of Development in River basins in Asia and the Pacific

Activity	Wetland Impacted	Example Impacts
Forestry management	Food plains of the Komering River, Indonesia	Increased erosion leading to increased sediment loading, silting up of wetland channels. Modification to extent, depth and duration of food plain inundation. Abandonment of rice fields.
Agriculture	Aral sea, Central Asia	Diversion of inflowing rivers for large-scale irrigation. Falling water level and declining sea extent. Rising salinity. Contamination of inflowing rivers with agricultural chemicals. Loss of deltaic wetlands. Disappearance of many fish species. Numerous health problems.
Urbanisation	Riverine wetlands of Klang Basin, Malaysia. Bhoj wetland, India	Channelisation of natural river channels. Pollution of rivers and streams. Increased soil erosion and higher sediment loads. City sewage, encroachment, eutrophication
Water resources development	Ganges flood plain wetlands, Bangladesh	Construction of Farakka Barrage across the Ganges in India. Diversion of water supplies and declining inundation of wetlands. Enhanced saline intrusion. Negative impacts to floodplain agriculture and fisheries
Hydro-electric power development	Mekong river	Several dams already constructed; many more planned. Modification to the natural flow regime of the river. Declining inundation of wetlands. Reduced freshwater inflow to coastal wetlands and disruption of salinity patterns and water levels within the delta
Land use planning	Floodplain wetlands of Bangladesh	Sectorally focussed planning for flood control and irrigation leading to extensive flood control, drainage and irrigation infrastructure. Major modification to floodplain functioning. Pollution of wetlands with agrochemicals.

Development activity within Wetlands

Wetland drainage	Peat swamp forests of the Lower BaritoBasin, Indonesia	Drainage of extensive areas for large-scale rice cultivation. acidification of soils leading to crop failures.
Aquaculture	Mangrove wetlands throughout SE Asia	Removal of tree cover and conversion to extensive single use ponds. Acidification of acid sulphate soils leading to higher salinity. Pollution of surrounding uncovered mangroves with highly saline water and other pollutants associated with aquaculture.
Wetland forestry	Peat swamp forests, Sarawak, East Malaysia	Extensive logging. Oxidation and erosion of peat. Cutting of canals through wetlands leading to reduced ground water levels and dry season base flows
Control structures: Dikes and embankments	Deltaic wetlands of Ganges, Meghna and Brahmaputra, Bangladesh	Removal of floodwater supply to wetlands. Increased downstream erosion. Water logging behind embankments. Disruption to fish migrations

Source: UNEP- Wetland International-Asia Pacific, "Wetlands and Integrated River Basin Management."

1.7 Biodiversity

Wetlands and deep fresh water habitats are extremely rich in their bio-diversity, particularly as they occupy a very small area of the earth's surface. Wetland functions and values are now well known but their bio-diversity has neither been properly inventoried nor its role duly recognised. Wetlands in South Asia exhibit great diversity in flora and fauna due to their climatic and topographical variation. The Himalayas in the north have acted as a two- way high way linking West Africa to Southeast Asia. At the eastern end through the "Assam gate" come the Chinese and Malayan elements and from the west come the palaearctic and European elements. In the Peninsula there may also have been a cross-over point between the South Western Ghats and the Eastern hills in the Indian subcontinent. In conjunction with other parts of Asia, the region is the global center of diversity for a number of ecosystems or species groups. The wetland flora is represented by all taxonomic groups from unicellular algae, bryophytes, mosses and ferns to woody angiosperms. Gopal (1995) reported the occurrence of 450 species of macrophytes in the Indian subcontinent, many of which are endangered and some of which have become extinct. Many of these species are endemic. There are several reports of declines in vegetation but little attention seems to have been focused on conservation of retreating population of macrophytes.

The mangrove vegetation shows considerable variation in different pats of the region. Only 8 mangrove species have been recorded in the Indus delta of Pakistan compared to about 60 species in the Sunderbans of the Ganges delta. High species diversity (65) has been reported in the Bhitarkanika area of Orissa

The faunal wealth in South Asian wetlands is equally diverse. The Sunderbans are the home of the threatened Bengal tiger *Panthera tigris*, the jungle cat *Felis chaus*, the leopard cat *Felis bengalensis*, and the fishing cat *Felis prinaclurus vevetina*. The wetlands of eastern Himalayas, extending to Bangladesh, are internationally important for a number of threatened bird species, notably Imperial Heron *Ardea imperialis*, Greater Adjutant *Leptoptilos dubius*, Jerdon's Bush-chat *Saxicola jerdoni*, Painted bush-quail *Perdicula manipurensis*, etc. The one horned Rhinoceros *Rhinoceros unicornis* has become confined to the remaining swamps of Assam. Loktak lake in Manipur state is the last refuge for Brow- antlered deer *Cervus eldi*

eldi. The wetlands of Bhutan harbour about 30-40%of the world population of black - necked Crane *Grus nigricolis*. The famous Keoladeo National Park wetland in India harbours about 370 species of birds including the highly endangered Siberian Crane *Grus leugeranus* in a wetland of just 76 km. Adjacent to this wetland, the riverine habitats of Chambal provide vital refuges for several species of wild life including Gharial *Gavialis gangeticus*.

Mountain streams in Himalayan range support many rare and interesting species such as the Relict Himalayan Dragonfly *Epiphlebia laidlevi*, a rare and poorly known species with very restricted range. In the Ladakh region of India, breeding colonies of Bar-headed Goose *Anser indicus* are found. Gahirmata in the eastern coast of India forms the largest turtle rookery in the world, where millions of Olive Ridley turtles visits for a brief period during January.(Trisal 1997)

1.8 Wise Use

Wise use of wetlands essentially involves conservation of the ecosystem while ensuring the sustainability of the benefits derived by mankind. The essential elements for achieving wise use are:

1. developing national wetland policy supported by legislative measures for regulation;
2. inventory,
3. improving institutional, organisational arrangements and overall capacity building;
4. increasing knowledge and awareness of wetlands and their values;
5. conservation of wetland sites

The planing, formulation and implementation of wise use of wetlands should involve local communities as they are the repository of knowledge on wetlands and have played a significant role in their conservation over thousands of years. It would be worth while to share their experiences in this regard. NGOs, too, are crucial for creating awareness and ensuring public participation(Trisal1997). Mudiali Fishermen's society located on the wetlands of south west Calcutta which has evolved a non-traditional system of wetland management. Using urban refuge and

polluted water of the city, the society has developed a completely indigenous bio-engineering system to perform three important functions:

1) improving the waste water quality before releasing it into the river Ganges,
2) using the waste water as input to grow fish, and
3) developing an ecologically balanced system to convert the entire area into a "Nature Park".

The above- mentioned functions have opened up further opportunities for an ever-increasing variety of business activities of the society, besides producing low-cost sanitation, employment, environmental safety and aesthetic values to the city dwellers. The evolution of Mudiali society over time can be looked upon as a tutorial system to provide lessons not only on economics and environment but also on how the fate of economics and environment can be dictated by exogenously given social and political factors. (Datta & Sinha,1996)

1.9 Wetlands of India

Most wetlands of India are directly or indirectly associated with the river systems. There are 14 major river systems, beside a large number of smaller rivers, which flow in all directions before discharging into the Arabian Sea or Bay of Bengal (Rao, 1975, Gopal and Krishnamurthy, 1993). The rivers Indus, Ganga and Brahmaputra and their major tributaries originate from the glaciers in the Himalaya and are perennial, owing their flow to both precipitation and snow melt. They form extensive floodplain and deltas. A few rivers originate from the Vindhyan Ranges in central India and flow northwards to meet the river Yamuna, the largest tributary of river Ganga (Gopal & Shah, 1993). The rivers originating in the peninsular region, mostly in the Western Ghats, depend entirely on the rainfall but are still perennial because of the very short dry period during the year. These rivers do not form large floodplains except that the rivers Krishna, Cavery, Godavari, and Mahanadi flowing eastwards form significant deltas along the eastern seaboard of India. River Narmada and River Tapti, originate in central India and flow westward along Satpura ranges. A number of small rivers, also originate in southern part of Western Ghats and flow westward in to the Arabian Sea. Natural lakes are relatively few and generally confined to the Himalayan belt (Fernando 1984, Gopal and

Krishnamurthy1993). All other natural fresh water bodies, often referred to as lakes, are floodplain lakes which are generally shallow (<3m deep) and exhibit large water level fluctuations depending upon the annual precipitation. (ILEC Report 1996)

Wetlands in India occupy some four million hectares of land. A survey by the Ministry of Environment and Forest in 1990 estimated that about 1.5 million hectares are under natural wetlands and man-made wetlands like tanks and reservoirs occupy 2.6 million ha. Mangroves according to the forest survey of India now cover an additional 453,300 ha. Some 80 % of the total mangrove area is found in the Andaman and Nicobar Islands. However according to the Directory of Asian Wetlands, wetlands in India occupy some 58.2 millions ha. and some 93 wetlands meet the criteria under Ramsar Convention.

Table - 1.3: Area of Wetlands in India (in million hectors)

Area under wet paddy cultivation	**40.9**
Area suitable for fish culture	**3.6**
Area under capture fisheries	**2.9**
Mangroves	**0.4**
Estuaries	**3.9**
Backwaters	**3.5**
Impoundments	**3.0**
Total	**58.2**

Source: Sustainable Wetlands, Environmental Governance-2, IGIDR, 1999

1.9.1 *Distribution*

The natural lakes or wetlands of India may be considered separately for the three major geomorphic regions, the Himalayan region, the Ganga - Brahmaputra floodplain, and peninsular India.

(i) Himalayan wetlands

Most of the natural wetlands in India lie in the Himalayan belt. They occur from the valleys up to an altitude of about 5000m although lakes in Tibet plateau occur at still higher elevation (Loffler, 1969). The Himalayan lakes have usually been grouped, according to the altitude, into three categories: Valley lakes, Forest lakes and High altitude

Wetlands. (Kaul 1977, Zutshi &Khan 1978). Zutshi et al. (1980) recognised the Sivalik lakes separately.

High altitude lakes are those lying above the timberline (3000m altitude), mostly along the Pir Panjal ranges and in Ladakh. They have generally been formed by glacial or tectonic activity. Forest wetlands are those lying amidst the pine forests in the Upper Karewas (outer fringes of Pir Panjal ranges in western Himalaya) at an altitude of 2000 to 2500m, e.g. Lake Nilnag.

The wetlands in the Kashmir valley at 1580-1600 m altitude, distributed in the floodplain of River Jhelum have been designated as Valley lakes. They are either Oxbow lakes or are still connected with the river. All of them are shallow with a mean depth of less than one meter to about three metres. Lake Manasbal is the deepest with maximum depth of only 12m.

The wetlands occurring at low altitude (600 m) in the Jammu region in the lower Sivalik Himalayan ranges, have been referred to as Sivalik lakes. These wetlands were probably formed by damming of the river some 10-15 thousand years ago. Among them better known are Lake Mansar and lake Surinsar.

Further eastward in the Himalaya, there are many small wetlands in Himanchal Pradesh between 600 and 4250m altitude. Of these, Renuka (620m), Rewalsar (1660m), Sukhsar, Dashalsar and Prashalsar (2300m) are better known. In the eastern Himalaya, there are only few small shallow lakes in Sikkim (for example, Yamdok Cho and Chamtodong) and in the north eastern hill regions (Lake Mikir in Darjeeling). These have not been fully documented.

(ii) Wetlands of Ganga- Brahmaputra Floodplain

These are numerous shallow water bodies in the floodplains of Ganga and Brahmaputra rivers. These are locally known as Tals, Jheel or Pokhar in Hindi speaking areas. And Bheel (or beel) in Bengal and

Assam, Pat (or Phat) in Manipur. These are generally Oxbow lakes nearly always associated with the rivers - often connected with them during the high flood periods. Among them the most significant are Kabar Tal or Lake Kabar in Bihar, Suraha Tal in eastern U.P., Deepor and Sareshwar beels in Assam, and Logtak lake, Waithou lake, Ikop phat, Khoidum phat, Phumlen phat and other phats in Manipur.

(iii) Wetlands of Peninsular India

In peninsular India, Lake Kolleru (Andhra Pradesh) is the largest freshwater lake along the eastern coast lying between the floodplains of River Godavari and River Krishna. Lake Kondakarla is another shallow freshwater lake in Andhra Pradesh. Elsewhere there are only few small shallow ponds.

(iv) Salt Lakes

In the arid and semi-arid region of Rajasthan there are a number of saline lakes of which Lakes Sambhar, Deedwana and Pachpadra and better known. Most of them are temporary, and dry up completely during the dry summer period. Their origin is not yet clear. It is likely that Lake Sambhar was once a freshwater lake. Presently they are closed basins receiving runoff from their sandy catchment, which is almost wholly denuded.

(v) Coastal Lagoons

Among the lagoons, the most important are Lake Chilika in Orissa (Ram et. al. 1994) and lake Pulicat in Tamil Nadu (Jhingram, 1992) on the east coast of India. Similarly there are several lagoons and backwaters in Kerala on the west coast (Jhingram, 1992). These lagoons, whose connection with the sea has usually been regulated with a weir, are generally referred to as lakes. The larger of these are Veli lake, lake Vemband and lake Sasthamkotta).

(vi) Urban wetlands

Perhaps the oldest among the large urban wetlands is the Upper Lake of Bhopal which was constructed in the early 11th century. Its large spread made it so famous that all other lake were considered to be simply 'ponds' in its comparison. The lower lake of Bhopal was created much later as the city started sprawling on that side. Other old and well known urban wetlands are those in Udaipur (Fatehsagar, Pichhola, Udaisagar and five other smaller lakes). Hyderabad (Hussain Sagar, Osmansagar), Ajmer (Anna Sagar and Foy Sagar), Jaipur (Mansagar and Jamwa Ramgarh), Jodhpur (Sardar Samand), and Alwar (Lake Silisher). Similar lakes are common near many urban centers in Madhya Pradesh (e.g. Sagar, Rewa), Karnataka and Gujarat. The recent man-made urban wetland, Sukhana Lake near Chandigarh and has attracted considerable attention due to the awful shrinkage rate and pollution. Some of the natural wetlands such as Dal Lake and Nainital lake are also truly urban lakes. (Gopal, 1996.ILEC Report)

1.9.2. *Major problems regarding wetland management in India*

The major problems confronting wetlands in India are:

(i) Siltation

About 3 million tonnes of silt is annually deposited in Chilka lake. The inflow of silt through rivers in ox-bow lakes has resulted in heavy sedimentation resulting in formation of large littorals colonised by dense macrophytic growth and shrinkage of lake area like Dal lake, Wular lake, Kabar lake etc. The problem of sedimentation is more pronounced in reservoirs resulting in the reduction of their water holding capacity and decrease in lake area.

(ii) Eutrophication

The process of water quality degradation caused by excessive nutrients is a serious problem confronting all wetlands in India excepting high altitude trans-Himalayan glacial lakes.

(iii) Pollution

These problems are particularly pronounced in urban wetlands like Hussain Sagar (Hyserabad, Andra Pradesh), Lower Lake (Bhopal, Madhya Pradesh), Dal Lake(Srinagar, Kashmir), etc. The impacts of pollution are quite evident by the toxic contamination of water like DDT, PCB, mercury, many other heavy metals and pesticides.

(iv) Prolific Growth of Aquatic Plants

The increase in levels of nutrients and heavy sedimentation have led to the prolific growth of aquatic plants. Some of the species which have reached nuisance proportions are: *Potamogeton pectnatus, Hydrilla verticillata, Myriophyllum* sp. The infestation of aquatic plants have resulted in reduction of open water area and their potential for water supply, navigation, fishing and recreational values.

(v) Invasion of Exotic Species

Severe problems encountered in Wetlands due to the invasion of exotic species like *Eichornea crassipes*, *Salvinia molesta, S. natans,* and *Azolla* sp. These species have profusely grown in the lakes posing threat to endemic species. The prolific growth of the weeds has led to the problems of anoxic (with out oxygen) conditions and changes in the flora and fauna. Similarly, introduction of exotic fish species has affected the genetic variability of endemic fish species.

(vi) Aquaculture

Large areas of wetlands particularly in coastal region have been converted for aquaculture leading to problems of salinisation,

eutrophication, and decrease in biodiversity. In some lakes like Kolleru, fish ponds have been constructed to maximise the fish production. The addition of fish feed, manures, antibiotics etc. have resulted in formation of algal blooms and drastic reduction in oxygen concentration. All these changes have seriously affected water quality in these wetlands.

(vii) Encroachment

Since wetlands are multiple value systems, areas have been converted for agriculture and other development activities. These intrusions have led to the shrinkage of the wetland area leading to adverse impacts on the ecosystems. The problem of encroachment is particularly pronounced in urban wetlands where conversion for settlements, industrial activities, and tourism has been going on without any check. The impact of human activities in the catchment area, particularly by diversion of river waters, can be seen in the way of changes in the hydrological regimes consequently affecting the water levels and causing fluctuations.(Kaul & Trisal 1996,ILEC Report)

A combination of all the above threats has resulted in shrinkage of the wetland area and decline in biodiversity and resource base and their potential to meet needs of the people dependent on these resources . Further these polluted aquatic systems are breeding ground for mosquitoes, snails, leeches and other vectors of many fatal diseases of mankind and livestock. These factors are not only more pronounced in tropical regions, but have also greater socio-economic important for the developing countries. Thus there is an urgent need for a systematic survey and inventorisation of all natural and man made fresh water aquatic ecosystems of India from ecological point of view to understand its structure and function in detail. (Naik, 1998)

1.9.3 *Conservation and Management of Wetlands*

Considering the importance and the pressures of human activities on the wetlands, the Government of India launched a programme for conservation and management of wetlands in 1986. A number of wetlands viz. Wular lake (J&K), Harike lake

(Punjab), Sukuna (Chandigarh), Renuka (Himachal Pradesh), Sambar lake and Pichola-Fathesagar (Rajasthan), Lower and Upper lakes of Bhopal (Madhya Pradesh), Loktak lake (Manipur), Ujni (Maharastra), Chilika (Orissa), Kolleru (Andhra Pradesh), Salt Lake (West Bengal), and Ashtamudi and Sasthamkota (Kerala), were selected for intensive conservation and management purposes. Management action plans were prepared by the concerned State Governments and financial support was provided by the Central Government for implementation of these plans based on the specific problems encountered in these wetlands.

Table 1.4: Lakes under NLCP for intensive conservation and management

Name of lake	State
Dal	Jammu and Kashmir
Bhoj	Madhya Pradesh
Sagar	Madhya Pradesh
Hussain Sagar	Andhra Pradesh
Nainital	Uttar Pradesh
Kodaikanal	Tamil Nadu
Ooty	Tamil Nadu
Powai	Maharastra
Udaipur Lakes system	Rajasthan
Sukhana	Chandigarh
Rabindra Sagar	West Bengal

Source: ILEC Report 1996

The Ministry of Environment and Forests, Government of India had launched the Ganga Action Plan in 1985, to check pollution in this river system and increase its assimilative and self-purifying capacity. The experience has been extremely useful to initiate activities for improving the water quality in other 13 major rivers in the country. Since lakes located in urban areas are subject to heavy loads of pollution and other anthropogenic pressures, the National Lake Conservation Plan (NLCP) aims to check pollution and improvement of water quality in the selected lake ecosystems.The main objectives of the National Lakes Conservation Plan include the following:

(a). Prevention of pollution from point and non-point sources through interception, diversion and treatment of sewage, construction of low cost sanitation facilities, provision of bathing and washing ghats, etc.

(b) Catchment area conservation through afforestation and construction of micro-water sheds.

(c) Desilting and weed control through conventional methods of dredging and manual labour.

(d) R&D studies on floral and faunal activities and related ecological aspects.

(e) Other activities depending on the lake specific conditions such as integrated development approach including interface with human population.

CHAPTER II : ECONOMIC VALUATION OF NATURAL RESOURCES AND WETLANDS IN PARTICULAR

Nature has given a lot to mankind. Human beings survive on this planet by fulfilling all their needs through natural resources. Be it food, water or air, natural resources are essential for the survival of man. Unfortunately, the use of natural resources has not always been optimal. It rotates between gross overuse to misuse mainly because these resources have no price or a very nominal one attached to them. Efficient use of natural and environmental resources requires knowledge of the value of these resources in various uses (Prato, 1998). Market prices do not always reflect the full social cost of resource use. Many uses cannot be thus valued in the market place because of incomplete or non-existent markets.

2.1 Economic Value

Economic value can be defined as an attempt to assign quantitative values to the goods and services that are provided by environmental resources, whether or not market prices are available for them. The economic value of any good or service is generally measured in terms of what we are willing to pay for the commodity less what it costs to supply it (Barbier, Acreman and Knowler, 1997). The question that arises at this point is why value environmental resources at all. The answer to this question has been answered by many environmental scientists in the following way: The ever increasing population load is creating a number of problems for the natural resources stocks that we have. Pollution and unsustainable use have led to degradation and depletion of a number of these resources. We many a time are aware that a particular resource is important but in spite of that, we are unable to decide upon a wise use plan for the same. Many environmental resources are complex and multifunctional and we may not yet be aware of all the goods and services provided by these resources. The decision of using a resource and to what extent, or to conserve it for future use are very tricky and in fact cannot be planned properly without knowledge of *all the values* that are gained and lost under each of the resource use option possible, and careful consideration of the same. Preservation, sustainable use or total development, are the

usual options according to which a resource may be utilised or conserved. Thus valuation may serve to improve the management of environmental resources in a way that is suitable not only for the current generation but also for future generations. The economic efficiency of the various competing uses of the resource is thus the main criteria for deciding its pattern of consumption in the future. Economic valuation is actually concerned with the proper allocation of environmental resources in order to improve human welfare. It thus serves as a very important tool in the hands of the decision / policy maker.

2.2 Total Economic Value

The marketable and non-marketable benefits together constitute the total economic value of any resource. These can be of many types; mainly:

Use values: Use values involve some human interaction with the resource as is evident from the name itself. These may be of two types again - direct use values and indirect use values. The former is as the name suggests tangible in nature while the latter may be indirect in the form of an intangible benefit. The value obtained from the microclimatic stabilisation effects of a forest ecosystem, for example, for which the people do not pay anything, is an indirect use value. Since the indirect use values are actually unmarketed they become difficult to quantify and till now have been generally ignored in spite of being so important.

Option values: An environmental resource has option value if the future benefits it might yield are uncertain and depletion of the resource is effectively irreversible (Prato, 1998) - which is the case with most natural resources. In this case one may be willing to preserve the option, in the chance that it might prove valuable in the future. In this context quasi option value is defined as the expected value of the information derived from delaying exploitation and conversion of the resource today.

Existence values: Sometimes a resource may be having an intrinsic value known as existence value. It is a form of non-use value where the individual's moral concerns about environmental degradation, empathy for other species and the satisfaction that he

/ she derives from the mere existence of a certain resource which the person is not in direct contact with. Bequest value is a type of existence value where one would desire to leave an unspoiled planet for one's descendants.

Thus the total economic value of an environmental resource has also been expressed as:

TEV = DUV + IUV + OV + EV

Where, TEV = Total Economic Value

DUV = Direct Use Value

IUV = Indirect Use Value

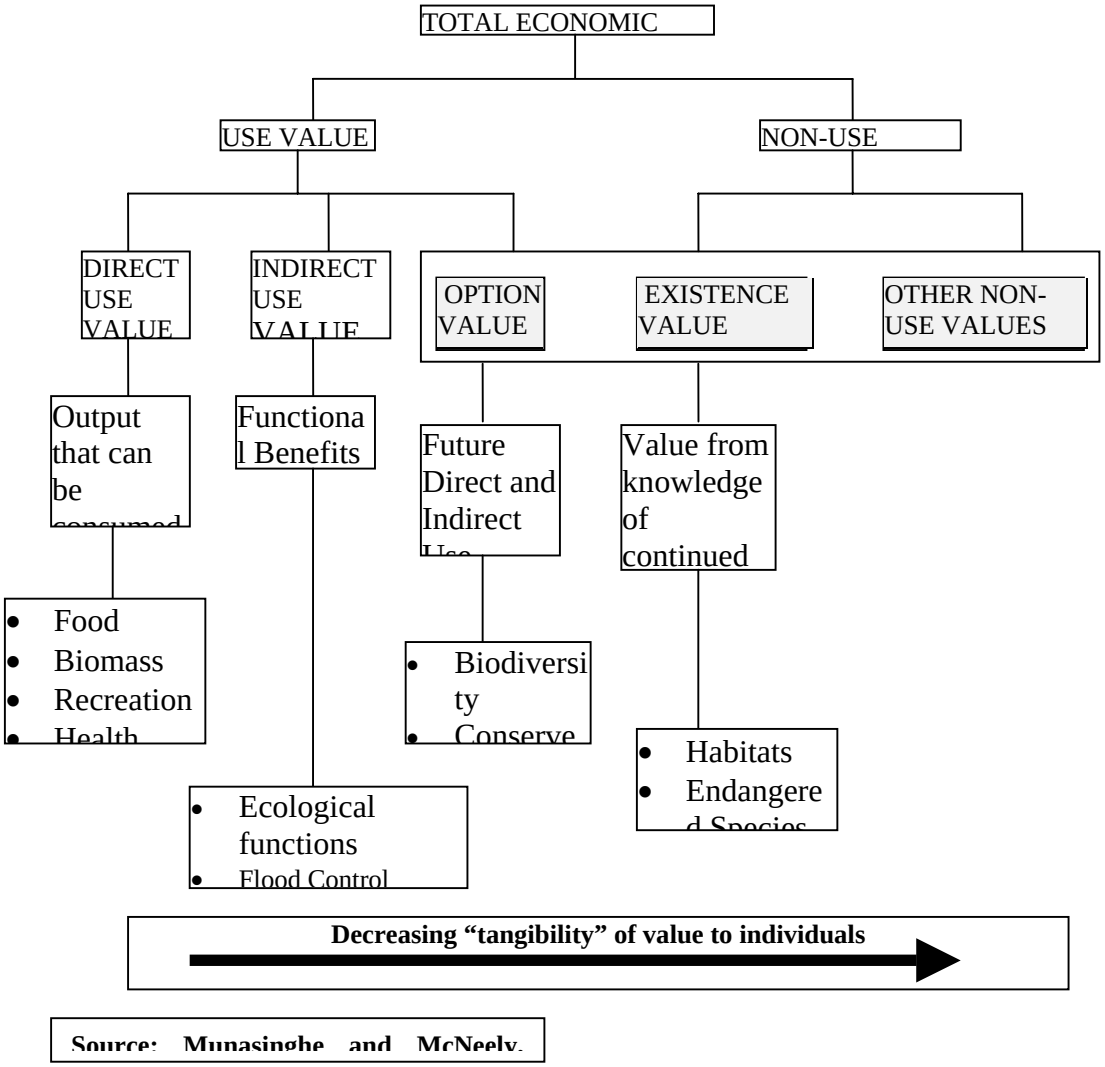
OV = Option Value

and EV = Existence Value

An example of the concept of TEV is being shown through the Fig 2.1 which takes into account all values emerging from an environmental resource, say a forest.

But again the pure additive form of the total economic value has not been accepted by all natural resource economists. Some writers regard intrinsic value as part of existence value rather than as its equivalent (Randall and Stoll,1983). On the other hand, others regard intrinsic value as being inclusive of option value (Fisher and Raucher, 1983). These variations in definitions most probably arise from what exactly is meant by 'use'. The concept of existence value and bequest value need further investigation since in some cases double accounting may easily take place in case the equation mentioned above is taken as it is. Therefore the uses have to be carefully defined in order to avoid problems that may arise in trying to separate various values.

Fig 2.1: Categories of Economic Values Attributed to Environmental Assets (With Examples from a Tropical Forest)



Source: Munasinghe and McNeely.

2.3 Valuation Methods

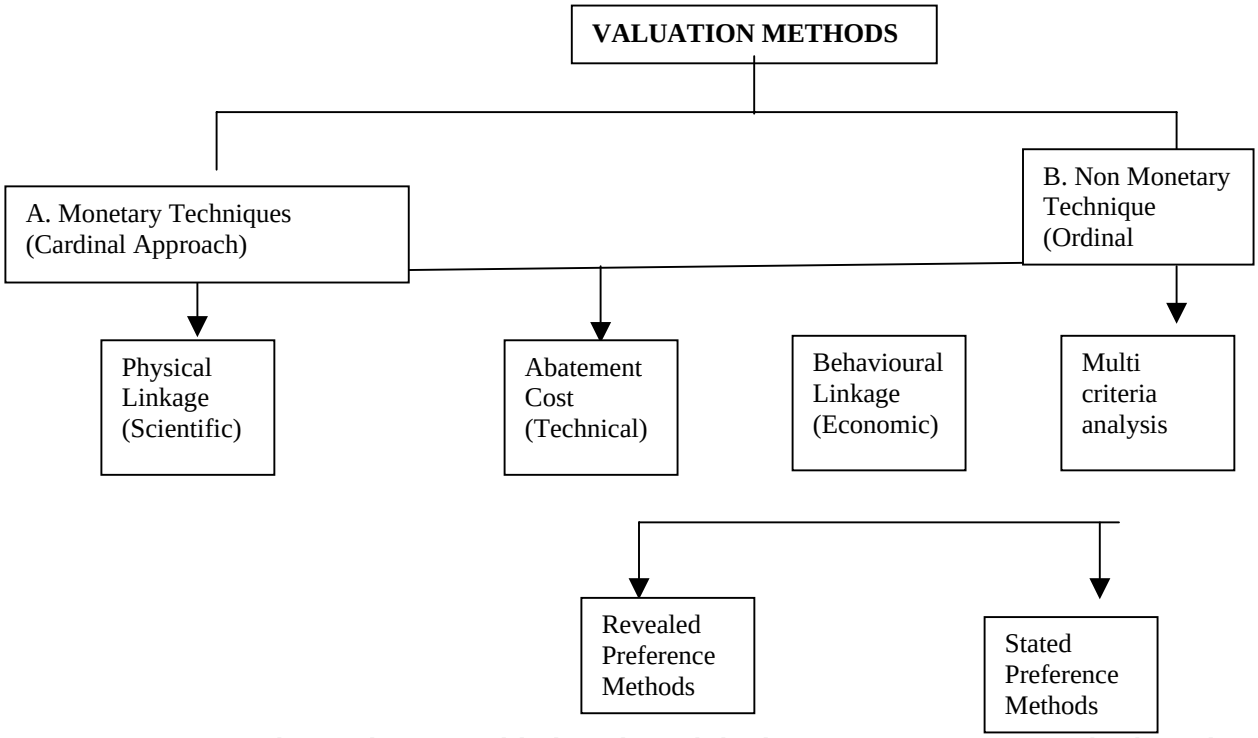
A variety of economic techniques and models have been developed for assigning monetary values to gains or losses associated with changes in the availability (quantity) or character (quality) of environmental amenities. The aim of these techniques is to obtain an estimate of the value of an environmental amenity that would be revealed if there were a competitive market for the amenity or stated in a survey. The values could be obtained either through direct valuation or through indirect valuation and thus could be expressed in monetary terms. But in some cases it is difficult to ascertain their

monetary values as only qualitative information like preferences, ordering, priorities or their presence or absence are available. In such cases non-monetary valuation techniques are used to capture the value of the resource. Valuation methods have been classified mainly into two categories (Fig: 2.2)

A. Monetary Techniques

Monetary valuation is a method of valuing goods and services at their market prices which are available directly or indirectly. In other words when the change in the environmental quality affects actual market-related production, it is captured through market prices. Such market may be conventional or existing or surrogate or implicit or constructed or simulated market based on actual or potential behaviour of the consumer.

Fig 2.2: Valuation Method



Source: ESCAP, 1997(A and B are added to the original structure to express the broad categories of valuation methods)

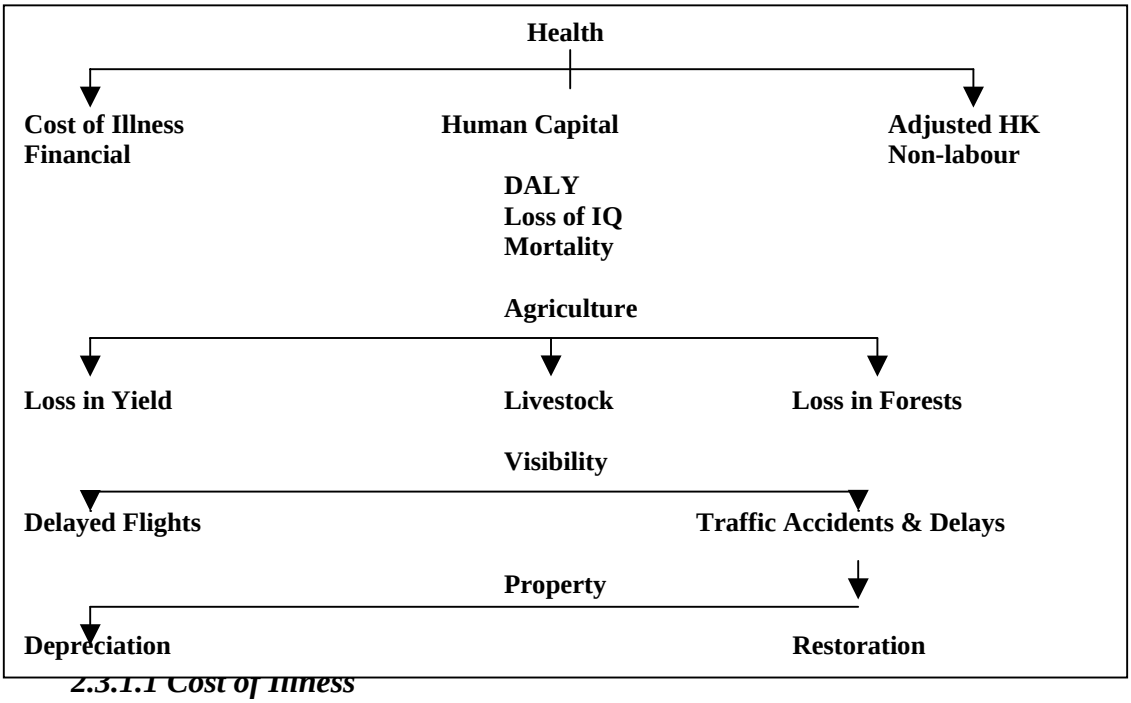
2.3.1 Physical Linkage Methods

Dixon and others (1994) termed these methods as objective but they are now known as scientific, because they depend on a cause and effect relationship between environmental change and other objects such as products, processes or persons. In the physical linkage approach, environmental values are estimated by establishing relationships between the physical effects of some environmental change on some other factors such as human health, productivity or earnings. Assessing the impact of pollution on ecosystems, on productivity of a fishery, or depreciation of a physical asset may also be necessary. The next step is to quantify these impacts and then value them to arrive at the value of the environmental changes. The physical linkage approach is also known as the damage cost or dose – response approach. Changes in net benefits as revealed in physical terms or market prices caused by environmental damage are actually to be measured. Alternatively, benefits can be measured as the increased productivity due to improved environmental quality. The physical linkage method can also be used to establish the loss in visibility and its impact on traffic accidents and delayed flights as expressed in figure 2.3.

The cost of illness (COI) measures the cost of environmental damage in terms of direct outlays for the treatment of illness (hospital care, cost of medicines, cost of the services of physicians and other medical personnel) plus indirect losses in output due to illness measured by social cost of lost earnings (Rezeler, 1993). The COI approach however, does not take into account the expenditure incurred by the individual to avoid illness, e.g. vaccines, the value of personal pain, suffering and inconvenience associated with the illness. This kind of expenditure or cost to avoid the illness or diseases is captured through the preventive cost approach in the revealed preference technique discussed separately in the defensive cost approach. The problems with COI technique are that a great number of people affected by diseases do not approach hospitals due to lack of awareness, accessibility and affordability. Moreover, the entire health care system is

heavily subsidised and hence an estimate based on actual expenditure will be far lower than the true expenditure and associated opportunity cost.

Figure: 2.3 Physical linkage methods.



2.3.1.1 Cost of Illness

Source: ESCAP, 1997

2.3.1.2. Human Capital Approach

The Human Capital (HK) approach for valuing morbidity assumes that the value of an individual is the potential of *production* the person possesses. Once the damage function is obtained, the essential factor is the unit economical value of the physical damage (mortality / morbidity). A product of the numerical values of both the number of people affected or dead and the unit cost of treatment or death will provide the monetary value of health damages (OECD, 1989). The HK method also fails to account for intangibles like pain and suffering. Yet, the adjusted HK method is considered to be the most appropriate method for evaluating environmental policies that involve risk to human life.

2.3.1.3. Statistical Value of Life

An alternative approach to the delicate question of valuing human life is to analyse the behaviour of people in paying for reduction in risk to their life or accepting compensation for undertaking risky jobs. There are a number of assumptions that have to be taken up for this method to be applicable, which are not always true for the Indian conditions. Thus there are also objections raised against use of this method.

2.3.1.4 Production Function Approach

Besides using market prices, productivity approach/production function approach can also be used to measure changes in the quality of resource. This approach tries to estimate the present value of loss in production / output now and in future. In case of measuring changes in productivity of soil, the approach could be to estimate the value of changes in soil quality based on loss in productivity and the possibility of restoring soil quality through ameliorative measures (Parikh K., 1990). While measuring quality by yield input relationship, yield is taken to be a product of a function (f) of inputs & another function (g) of soil quality parameter. The function f is called the input response function and function g the soil quality multiplier function.

Yield = f (inputs) g (soil quality parameters)

The first objective is to obtain an estimate of soil quality multiplier in terms of easily observable and measurable parameters. The amount of potential yield or profits forgone due to a lower value of soil quality multiplier is a measure of the cost of depreciation of soil (ESCAP, 1997). The soil quality multiplier is determined by a set of inherent physical and chemical properties of soil. In such a case the percentage change in present value of annual property from land (V) shall be same as the percentage change in the value of soil quality function of (Q). This could be expressed as :

$$\frac{V^*(Q0) = V^*(Q1)}{V^*(Q0)} = \frac{g(Q0) - g(Q1)}{g(Q0)}$$

Percentage change in Value of land = Percentage change in value of soil quality function.

Thus in a competitive set up

Cost of land Degradation = Min [(Avoidence cost) , (Restoration Cost), (Loss in productive asset value)]

In the same manner the cost of degradation of wetlend could be measured where we could use water quality parameters. Changes in water quality parameters like total colliform organisms, pH value, Dissolved Oxygen Demand and Biochemical Oxygen Demand could be assessed to find out how the quality of water has changed from A class that is drinking water without conventional treatment to other classes may be B (outdoor bathing) or C (drinking water source after conventional treatment and disinfect ion), or D (propagation of wildlife and fisheries) or E(irrigation and industrial cooling, controlled waste disposal).

Further if the wetland is also used as a productive asset in case of fisheries, the changes / deterioration in water quality shall also affect the fish production. Thus loss in earning due to fall in fish production could also be as an indicator of falling wetland productivity.

2.3.2. The Abatement Cost Methods

The abatement costs methods looks at valuation from the supply angle as opposed to the other two methods, which approach it from the point of view of demand for environmental amenity. These are known as *technical* methods or the *maintenance cost* method as this cost would maintain the environmental quality at a constant level. For example, installation of electrostatic suspended precipitators tso remove suspended particulate matter (SPM) from a boiler or furnace, etc. The value of damage due to a

tonne of SPM can thus be calculated as the cost of removing one tonne of SPM. This is the capital cost of the abatement equipment annualised over the life- time of the equipment with the annual variable cost added to it.

In developed countries, the marginal abatement cost is likely to be nearly equal to the marginal social cost. Therefore abatement costs can be used as proxy social cost. But in developing countries, this does not always happen. The marginal social cost may exceed the abatement costs but yet, nothing may be done. Thus, the abatement cost approach should be followed only if the abatement costs have actually been incurred. Otherwise the damages experienced by society – in the absence of abatement measures – should be worked out.

2.3.3. Behaviour Linkage Methods

Valuation techniques assume that the value of an environmental resource is equal to the people's willingness to pay (WTP) to secure better environmental quality or to escape environmental deterioration. Classification of these techniques that seek to estimate behavioural parameters are based on whether the results are revealed in the market place or stated in a survey. These are also of two types:

2.3.3.1 Revealed Preference Methods

In the revealed preference methods the value of an environmental amenity is estimated indirectly from the purchase price of a commodity whose market value at least partly depends upon the quality of the environmental amenity in question. The value of an unpriced amenity like environmental quality or scenic beauty is inferred by using statistical analysis to examine how a change in amenity affects the observed purchase price offer related private good. These methods are based on actual information revealed in the marketplace.

Cost of avoidance or Preventive Cost

Cost of avoidance (COA) or Preventive Cost approach takes into account the expenditure incurred by individual to avoid illness. For example to avoid the incidence of

water borne diseases people resort to water treatment devises like filters, aquaguard, zero B or boil water or go for vaccination of Hepatitis B or A to prevent themselves from water borne diseases. Similarly people use mosquito coils, nets or spray's at home to avoid malaria or wear helmets to avoid fatal head injuries in case of accidents. Many a times it is observed that the cost of averting illness is much less than the expenses incurred on curing illness and thus this expenditure is preferred by consumers over the cost of curing the illness.

Travel Cost Method

Travel cost method is a market - based approach for estimating nonmarket values. It is mainly used to measure the benefits associated with recreational resources, such as parks, rivers, or beaches (Goodstein, 1995). The idea behind this method is to measure the amount of money that people spend in order to utilise a particular resource. Demand is estimated by relating the number of visits to the cost per visit. This method recognises that the visitors who reside farther away from the site incur a higher travel cost than visitors who reside near the site. Thus, this method actually uses the variation in the cost of traveling to a particular site (travel cost) as a proxy for variation in the cost per visit.

The basic travel cost method was first discussed by Hotelling. The theoretical basis for this method lies in the household production function theory developed by Becker, Lancaster, Hori and Bockstael and Mc Connell.

The travel cost method has certain limitations and ambiguities, some of which have been remedied over the years. These usually include exclusion of non use values such as option, existence and bequest values, selection of the variable for measuring use rates (number of visits or visitor days), downward bias in estimates of consumer surplus from omitting time cost and the price of substitute sites from the demand function, valuing the opportunity cost of travel time and on-site time, accounting for multiple characteristics of a site and multiple reasons for visiting a site, and choice of the mathematical form of the travel cost demand function (Prato, 1998).

Hedonic Pricing

The word *hedonic* means pertaining to pleasure; the hedonic pricing method estimates the pleasure or utility associated to with an improved environment. The value of a piece of land is related to the streams of benefits to be derived from the land. Agricultural output and shelter are the most obvious of such benefits, but access to the workplace, to commercial amenities and to environmental facilities such as parks, and the environmental quality of the neighbourhood in which the land is located are also important benefits which accrue to the person who has the right to use a particular piece of land (Pearce and Turner, 1990).

The hedonic pricing method is based on the premise that the observed market price of a marketed good is a function of the prices of the numerous attributes of that good. For example, the incremental value of owning a house with a scenic view is the price of a house with a scenic view minus the price of a house without a scenic view, provided all other attributes of the two houses are similar. It is well known that differences in residential property values can arise from any sources, such as the amount and quality of accommodation available, the accessibility of the central business district, the level and quality of taxes that have to be paid on the property, and the environmental characteristics of the neighbourhood, as measured by the levels of air pollution, traffic and aircraft noise, and access to parks and water facilities. In order to pick up the effects of any of these variables on the value of a property, they all have to be included in the analysis. Hence such studies usually involve a number of *property* variables, a number of *neighbourhood* variables, a number of *accessibility* variable and finally the *environmental* variables of interest. If any variable that is relevant is *excluded* from the analysis then the estimated effects on property value of the included variables could be biased. Whether the bias is upward or downward, depends on how the included and the excluded variables relate to each other and to the value of the property. On the other hand, if a variable that is irrelevant is included in the analysis then no such systematic bias results, although the estimates of the effects of the included variables are somewhat less reliable. Typically, many of the variables of interest are themselves very closely correlated. So, for example, accessibility to the town centre is often closely

related to some measures of air pollution, and one measure of air pollution such as total suspended particulate matter, is very closely correlated to other measures such as sulphur dioxide. To overcome this, many studies use only one ‘representative’ measure of pollution (Pearce & Turner, 1990)

The first stage in the hedonic price approach, then, is to estimate an equation of the form:

Property price = f(property variables, neighbourhood variables, accessibility variables, environmental variables)

Or, symbolically,

PP = f(PROP, NHOOD, ACCESS, ENV)

Where, f(…) simply means ‘is a function of’(depends upon). This equation can be further expressed as:

$$\ln PP = a\ln PROP + b\ln NHOOD + c\ln ACCESS + d\ln ENV$$

where, ‘ln’ simply refers to logarithm. By feeding in the observed values for property prices, the property variables, the neighbourhood, accessibility and environmental variables, a simple computer program will generate the values of a, b, c and d. In this case, the value of d will tell us how much property prices vary if we alter the value of the environmental variable (Pearce & Turner, 1990). Alternatively property prices can be examined to detect any premium paid for location with the desired amenity (Streeting, 1990). The premium can be taken to reflect the value of the amenity.

The hedonic price function is typically estimated using regression analysis. Several drawbacks of the method exist. Marginal prices are not accurate unless all the attributes are included in the hedonic price function. Data for estimating the hedonic price function are often difficult to acquire, especially for goods that have slow turnover rates. Further households may not be aware of differences in the attributes being valued.

2.3.3.2 Stated Preference Methods

This methods differ from the methods presented above as they are employed when little or no actual market information exists as a proxy value. These methods assume that people respond to hypothetical market situations as if they were actual markets. The methods rely upon what people *say* they would buy, if the market existed. In this event, a representative sample survey of human population is conducted to collect specialized data on their willingness to pay (WTP) to secure a benefit or their willingness to accept (WTA) a compensation to bear a loss or damage. Based on these responses the value of good or a service for each person questioned can be determined and then extrapolated to estimate the aggregate effect on the target population. Some of these important methods are discussed below.

Contingent Valuation Method

The contingent valuation method first came into use in the early 1960s when economist Robert K.Davis used questionnaires to estimate the benefits of outdoor recreation in a Maine backwoods area. According to Davis, 1963, this method would put the interviewer in the position of a seller who elicits the highest possible bid from the user for the services being offered. The ultimate aim of a contingent valuation survey is to typically obtain an accurate estimate of the benefits (and sometimes the costs) of a change in level of provision of some public good, which can thus be used in a benefit-cost analysis.

The CVM uses survey questions to elicit people's preferences for public goods by finding out what they would be willing to pay for specified improvements in them. The method is thus aimed at eliciting their willingness - to - pay (WTP) in monetary terms (Mitchell and Carson, 1989). The idea is to compensate for the absence of markets for the goods and services being valued by presenting the consumers with hypothetical markets in which they can buy the good in question. Because the elicited WTP values are contingent upon the particular hypothetical market described to the respondent, this approach came to be called the contingent valuation method (Brookshire and Eubanks, 1978; Brookshire and Randall, 1978; Schulze and d'Arge, 1978).

The CVM is thus actually a public survey in which the respondents are presented with material, in the form of a personal interview usually, which consists of three parts (Mitchell and Carson, 1989):

1. A detailed description of the good(s) being valued and the hypothetical circumstance under which it is made available to the respondent.

2. Questions which elicit the respondent's willingness to pay for the good(s) being valued.

3. Questions about respondent's characteristics (for example, age, income), their preferences relevant to the good(s) being valued, and their use of the good(s).

In case of a well designed and carefully pretested study, the respondents' answers to the valuation questions should represent valid WTP responses. From these a benefit estimate is developed. The results are then generalised with a known margin of error to the population from which the respondents were sampled. It has been found by many people that the respondent's value statements are highly dependent on the information contained in a CVM questionnaire (Fischoff and Furby, 1988).

The CVM is based on two major principles of neo-classical economics (Hoevenagel, 1994). These are:

i) Value of any good depends on its utility to individuals, and

ii) Individuals behave rationally, that is they will maximise their utility.

Private Goods Market Model

In a private goods market model, a scenario is usually described to the respondent where the opportunity to obtain the benefits of amenities is offered at a range of prices. This model is best suited to quasi-private goods such as access to beaches, fishing rights or any other amenity, where a permit to access (to the exclusion of others) is feasible. Application of this model to public environmental amenities, such as clean air,

tend to be less successful as the procedure usually requires the respondents to imagine that they can own and use the amenity to the exclusion of other persons.

The elicitation method often used in the private goods model is a bidding game technique designed to resemble an auction. The interviewer raises or lowers the bid until the respondent decided to make a purchase, thereby revealing his maximum willingness to pay. In an open-ended question, the opening bid or the final valuation can be stated by the respondent without any prompting. In a close-ended format, respondents are asked to answer ‘yes’ or ‘no’ to a proposed payment.

The Referendum Method

In the referendum method, respondents are asked whether they would be willing to pay or sacrifice a specific amount of money in order to preserve the environmental amenity in question. A referendum can also be held about a specific action, where there is a discrete choice, and the answer can only be yes or no. A range of amounts are put to a number of subsamples. The referendum model can be used to elicit respondents’ votes on a tax level or the tax rate for the provision of a public amenity. It has been extensively used in the developing countries. For example, in Austria, a nuclear power plant already built at Zwentendorf was mothballed following a referendum. The value of foregone benefits and additional expenses for alternative electricity could be considered as the cost of avoiding risks of nuclear power.

B. Non – Monetary Techniques

Non-Monetary or ordinal valuation techniques value good and services to reflect utility and preferences of the consumers in the absence of markets. It is based on qualitative information like preferences, ordering or priorities for goods and services as expressed by wide spectrum of the society. It is based on the premise that the higher the preference or dependence on a resource, higher will be the value assigned to it by the people. The relative value of a resource can be measured by a score and rank obtained from ordering assigned to uses. A technique known as ‘Multi Criteria Analysis’ (MCA)

can be used to convert such ordinal or relative information into quantitative weights for different resource uses to elicit its use and non use values.

2.4 Factors Affecting Values

Factors that affect a person's assignment of value to an object (e.g. a good, situation or possible outcome) can be grouped into those factors that the person brings to the valuation situation and those that characterise the valuation situation itself. Factors that the person brings to the valuation include:

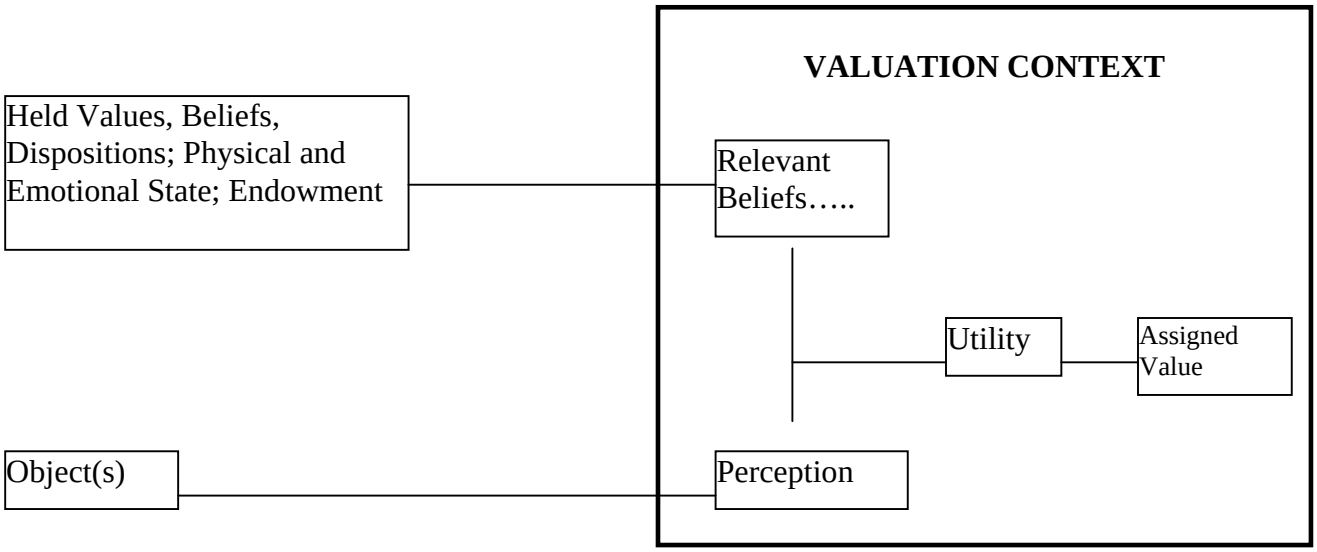
1. a collection of held values (Brown, 1984; Rokeach, 1973), beliefs, and dispositions

2. a physical and emotional state; and

3. an endowment of current and expected assets (figure 2.4)

Various factors characterising the context of the valuation include response mode, relative magnitudes, order effects, stimulus mixture, informational cues, constituency, iterations of valuation, and social setting.

Fig. 2.4 : Framework for Assignment of Value to Objects



Source: Brown and Slovic, 1988

2.5 Valuation of Wetlands

Wetland resources today are fast depleting and a major reason for this and the conversion of wetlands to other forms of land systems is that most of the benefits from the wetlands are non-marketable and hence not valued at all. This holds true mainly for the environmental and recreational benefits obtained from wetlands. Development of wetlands often leads to loss of environmental benefits but these losses are naturally understated since they have never been valued due to the lack of a suitable market for them. Valuation is thus an important step towards improving the management of these wetlands.

But a major difficulty that faces economic valuation of wetlands is the lack of information regarding the complex environmental system and the ecological and hydrological processes that result in the values. Because of this the valuation attempted may turn out to be grossly understated at times.

Total Economic Value for wetlands has been shown for wetlands to exist as the following mainly:

Table 2.1: Classification of Total Economic Value for Wetlands

USE VALUES			**NON-USE**
Direct Use Value	Indirect Use Value	Option and Quasi-Option Value	Existence Value
- Fish - Agriculture - Fuelwood - Recrecation - Transport - Wildlife harvesting - Peat/energy	- Nutrient retention - Flood control - Storm protection - Ground water recharge - External ecosystem support - Micro climatic stabilization - Shoreline stabilization, etc.	- Potential future uses (as per direct and indirect use) - Future value of information	- Biodiversity - Culture, heritage - Bequest values

Source: Barbier, Acreman & Knowler, 1997

Most of the ecological services, biological resources and amenity values provided by wetlands are in the form of what are known as *public goods.* Since these kinds of goods are not marketed and are obtained for free, these benefits and values are considered to have the same virtue, that is they are believed to be free goods. As per the principles of the Ramsar Convention, wetlands are believed to have great value. Conservation of these fast depleting wetlands would be possible if these wetlands can be shown to have immense value and in cases, more value than the alternative uses of the wetland site or

the water feeding it. Hence, valuation can result in the saving of the wetland from death, in the form of conversion to other uses.

2.6 Contingent Valuation Method in Detail

Contingent Valuation Method being the method to be used in the study, some important concepts and issues are being described here in details along with a section on literature review.

2.6.1. Validity of CV Studies

Validity refers to the extent to which an instrument measures the theoretical construct under investigation, (Mitchell and Carson, 1989). In other words, it can be expressed as the amount of money that the respondent would actually pay up, if a market for the good really existed (Hoevenagel, 1994). The validity of CV is very difficult to determine because the true values of any commodity, even those bought and sold in the market, is unknown (Smith, 1991). The main way of inferring validity for CV studies has been to compare values derived from a contingent valuation survey with values for the same good derived from other valuation methods but again the validity of these methods too is under question. There have been a number of such comparative studies, which prove that similarities between values thus obtained do exist. Thus it can be said that CV can provide reasonable estimates of the value of environmental goods. Statistical methods like regression can be used to test the internal validity of this survey technique.

2.6.2. Reliability of CV Studies

Reliability refers to the extent to which the variance in the elicited WTP values results from random sources (Hoevenagel, 1994). Thus efforts have to be made to increase the reliability of the results of a CV survey, because the more random the respondent's WTP amounts, the greater the chance that a study's mean WTP amount could be very different from the true amount for the good. Some variance is inevitable in contingent valuation estimates, of course. But CV studies using relatively small samples or having scenarios that respondents find unclear or unrealistic could obtain estimates, which differ from a true mean by large amounts. As a basis for making benefit-cost

determinations, their findings can easily be meaningless (Mitchell and Carson, 1989). The variance in the WTP amounts may be due to two sources: i) the variance introduced by the sample and ii) the variance introduced by the instrument. Techniques are available to measure the variance due to both. Unfortunately, these procedures are expensive to carry out properly, and for that reason they are not performed routinely in sample surveys.

For the former type of variance, a large sample size should be used. While for the instrument reliability, a first requirement is to create a realistic, plausible and meaningful CV scenario. This is because a more realistic scenario will generate similarly realistic values rather than mere guesses. But care has to be taken in order to avoid biases that may creep in during the effort to create a more real situation. A general way of examining the reliability of such surveys is through assessing the consistency of the stated WTP values over time (Hoevenagel, 1994).

2.6.3. Biases in CVM

The CVM arises out of the basic assumption that intentions reflected actual behaviour, that is stated WTP reflects actual WTP (Bateman). Attitudes are supposed to affect behaviour but cannot be taken to be exactly identical to the same. Moreover behavioural feed-backs can affect future attitudes. A biased survey is that in which the respondent may consciously or unconsciously modify stated WTP to differ from actual WTP. There exist many kinds of biases. A description of these biases is provided in the table below in order to obtain a proper view of the same.

Table 2.2 Typology of Potential Response Effect Biases in CV Studies

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1. Incentives to Misrepresent Responses

Biases in this class occur when a respondent misrepresents his or her true WTP

A. Strategic Biases:

Where a respondent gives a WTP amount that differs from his or her true WTP amount (conditional on the perceived information) in an attempt to influence provision of the good and / or the respondent's level of payment for the good.

B. Compliance Bias:

1. *Sponsor Bias:* Where a respondent gives a WTP amount in an attempt to comply with the presumed expectations of the sponsor (or assumed sponsor).
2. *Interviewer Bias:* Where a respondent gives a WTP amount that differs from his or her true WTP amount in an attempt to either please or gain status in the eyes of a particular interviewer.

2. Implied Value Cues

These biases occur when elements of the contingent market are treated by respondents as providing information about the "correct" value for the good.

A. Starting Point Bias:

Where the elicitation method or payment vehicle directly or indirectly introduces a potential WTP amount given by a respondent. This bias may be accentuated by a tendency to yea-saying.

B. Range Bias:

Where the elicitation method presents a range of potential WTP amounts that influences a respondent's WTP amount.

C. Relational Bias:

Where the description of the good presents information about its relationship to other public or private commodities that influence a respondent's WTP amount.

D. Importance Bias:

Where the act of being interviewed or some feature of the instrument suggests to the respondent that one or more levels of the amenity has value.

E. Position Bias:

Where the position or order in which valuation questions for different levels of a good (or different goods) suggest to respondents how those levels should be valued.

Scenario Misspecification

Biases in this category occur when a respondent does not respond to the correct contingent scenario. Except in A, in the outline that follows it is presumed that the intended scenario is correct and that the errors occur because the respondent does not understand the scenario as the researcher intends it to be understood.

A. Theoretical Misspecification Bias:

Where the scenario specified by the researcher is incorrect in terms of economic theory or the major policy elements.

B. Amenity Misspecification Bias:

1. *Symbolic:* Where a respondent values a symbolic entity than the researcher's intended good.
2. *Part - Whole:* Where a respondent values a larger or smaller entity than the researcher's intended good.
    a. *Geographical Part-Whole:* Where a respondent values a good whose spatial attributes are larger or smaller than the spatial attributes of the researcher's intended good.
    b. *Benefit Part - Whole:* Where a respondent includes a broader or a narrower range of benefits in valuing a good than intended by the researcher.
    c. *Policy-package Part - Whole:* Where a respondent values a broader or a narrower policy package than the one intended by the by the researcher.

1. *Metric:* Where a respondent values the amenity on a different (and usually less precise) metric or scale than the one intended by the researcher.
2. *Probability of Provision:* Where a respondent values a good whose probability of provision differs from that intended by the researcher.

A. Context Misspecification Bias:

1. *Payment Vehicle:* Where the payment vehicle is either misperceived or is itself valued in a way not intended by the researcher.
2. *Property Right:* Where the property right perceived for the good differs from that intended by the researcher.
3. *Method of Provision:* Where the intended method of provision is either misperceived or is itself valued in a way not intended by the researcher.
4. *Budget Constraint:* Where the perceived budget constraints differs from the budget constraint the researcher intended to invoke.
5. *Elicitation Question:* Where the perceived elicitation question fails to convey a request for a firm commitment to pay the highest amount the respondent will realistically pay before preferring to do without the amenity. (In the discrete - choice framework, the commitment is to pay the specified amount).
6. *Instrument Choice:* Where the intended context or reference frame conveyed by the preliminary nonscenario material differs from that perceived by the respondent.
7. *Question Order:* Where a sequence of questions, which should not have an effect, does have an effect on a respondent's WTP amount.

Source: Mitchell and Carson, 1989

The summarisation of problems regarding methodological issues in CVM identified by the National Oceanic and Atmospheric Administration Panel (Arrow et al., 1993) can be described as follows:

1. The difficulty of external validation of contingent valuation results.
2. Results that are inconsistent with the tenets of rational choice.
3. Results that seem implausible large in view of the many environmental goods which may need to be paid for.
4. The few contingent valuation applications that remind respondent's of budget constraints and substitute goods.
5. Difficulties in communicating complex scenarios to respondents so that they understand and answer the question intended by the researcher.
6. Issues of what population value estimates should be aggregated over.
7. The 'warm glow' effect where respondents are expressing WTP for the good feeling from giving rather than payment for the good in question.

Guidelines for the same have also been formulated by the same panel for carrying out contingent valuation.

1. *Sample type and size:* Probability sampling is essential. The choice of sample – specific design and size is a difficult, technical question that requires the guidance of a professional sampling statistician.
2. *Minimise non-responses:* High non-response rates would make CV survey results unreliable.
3. *Personal Interview:* It is unlikely that the reliable estimates of values can be elicited with mail surveys. Face-to-face interviews are usually preferable, although telephone interviews have some advantages in terms of cost and centralised supervision.

4. *Pretesting for interviewer effects:* An important respect in which CV surveys differ from actual referenda is the presence of an interviewer (except in the case of mail surveys). It is possible that interviewers contribute to 'social desirability' bias, since preserving the environment is widely viewed as something positive. In order to test this possibility, major CV studies should incorporate experiments that assess interviewer effects.

5. *Reporting:* Every report of a CV study should make clear the definition of the population sampled, the sampling frame used, the sample size, the overall sample non-response rate and its components (such as refusals), and item non-response on all important questions. The report should also reproduce the exact wording and sequence of the questionnaire and of other communications to respondents (such as advance letters). All data from the study should be archived and made available to interested parties.

6. *Careful pretesting of a CV questionnaire:* Respondents in a CV survey are ordinarily presented with a good deal of new and often technical information, well beyond what is typical in most surveys. This requires very careful pilot work and pretesting, plus evidence from the final survey that respondents understood and accepted the description of a good or service offered and the questioning reasonably well.

7. *Conservative design:* When aspects of a survey design and the analysis of the responses are ambiguous, the option that tends to underestimate willingness to pay is generally preferred. A conservative design increases the reliability of the estimate by eliminating extreme responses that can enlarge estimated values wildly and implausibly.

8. *Elicitation format:* The willingness to pay format should be used instead of compensation required because the former is the conservative choice.

9. *Referendum format:* The valuation question generally should be posed as a vote on a referendum.

10. *Accurate description of the programme or policy:* Adequate information must be provided to respondents about the environmental programme that is offered.

11. *Presting of photographs:* The effects of photographs on subjects must be carefully explored.

12. *Reminder of substitute commodities:* Respondents must be reminded of substitute commodities. This reminder should be introduced forcefully and directly prior to the main valuation to ensure that the respondents have the alternatives clearly in mind.

13. *Temporal overaging:* Time dependent measurement noise should be reduced by averaging across independently drawn samples taken at different points in time. A clear and substantial time trend in the responses would cast doubt on the 'reliability' of the value information obtained for a CV survey.

14. *'No-answer' option:* A 'no answer' option should be explicitly allowed in addition to the 'yes' and 'no' vote options on the main valuation (referendum) question. Respondents who choose the 'no-answer' option should be asked to explain their choice.

15. *Yes/No follow ups:* 'Yes' and 'no' responses should be followed up by the open-ended question : 'Why did you vote yes/no?"

16. *Cross-tabulations:* The survey should include a variety of other questions that help interpret the responses to the primary valuation question. The final report should include summaries of willingness to pay broken down by these categories (such as income, education, and attitudes toward the environment).

17. *Checks on understanding and acceptance:* The survey instrument should not be so complex that it poses tasks that are beyond the ability or interest level of many participants.

2.6.4. CVM Review

Till date, a number of valuation studies have been undertaken but mainly in the United States of America. There have been a number of studies that have also been carried out in developing countries and which have proved the validity of contingent valuation studies as a scientific method.

Desvousges and Smith, 1987, in their study of option price estimates for water quality of the Monogahela River, confirm that contingent valuation surveys seem capable of providing order - of - magnitude estimates of the benefits realised from enhancing one or more aspects of environmental quality. Furthermore these benefit estimates need not be confined to user-related values. Individuals can understand and incorporate values derived from uncertain future use into their bids for environmental improvement. Besides, question format may be important to the estimates of option price.

Nandini Hadker, Sudhir Sharma, Ashish David, T.R. Muraleedharan, 1997, in their study of the Borivli National Park conducted a survey of the residents of Bombay city to elicit their willingness-to-pay for the maintenance and preservation of Borivli National Park (BNP) using the CVM. They have paid special attention to several types of biases including hypothetical bias, starting point bias, embedding effects and part-whole biases. In order to mitigate the effect of these they have used special survey and statistical techniques. For a developing country like India their results show that in spite of medium to low income levels, people are willing to pay exclusively for the BNP on an average Rs 7.5 per month, for the next five years. Extrapolating this to the city of Bombay, this amounts to Rs 20 million each month for the next five years, or a present discounted value, in excess of Rs 1 billion.

Sandra Goodman, Shabbar Jaffry and Bill Seabrook, present the results of a study focussing on non-use values for the British coast. Considering that the British public uses the coast extensively and for a number of varied reasons, this study attempts to capture the total economic value of the coastal resources. A study of the relationship between conservation and non-use values has also been attempted in an exploratory manner. They also state that at times the public and the scientist’s viewpoint regarding

acceptable and ecologically preferable management strategies may considerably differ though there may be a reasonable degree of congruence between scientific and public perceptions of conservation value. It is stressed in this paper that rational policy decisions affecting environmental resources should always include elements of scientific analysis and public values.

Steven Schultz, Jorge Pinazzo and Miguel Cifuentes, 1998, in their study determining National Park Entrance Fees in Costa Rica, try to determine foreign and resident willingness to pay (WTP) for return visits to two different Cost Rica National Parks, in 1995. Results of this study indicate that the mean WTP for entrance fees differed among the National Parks and were considerably higher than the current fees. This study proves that even in a developing country scenario a contingent valuation study can be used to obtain the entrance fee structure of national parks. The authors recommend further research in the field of cultural-strategic biases in developing countries regarding this mode of surveys.

Richard T. Carson, 1998, in his paper on valuation of Tropical Rainforests focuses on theoretical aspects that explore the possibility of using a large scale multi-country contingent valuation study for making decisions concerning global resources in the specific context of valuing a large set of tropical rainforests. The paper addresses both philosophical and practical issues related to the use of CV including the role of passive use motives such as altruism and the role of information. Mainly the practical difficulties likely to be encountered in actually implementing a large contingent valuation study in multiple countries with a common set of tropical rainforests are presented.

Kristin Magnussen and Olvar Bergland, 1997, have tried to value the environmentally hazardous substances in water. : This paper is part of a project that aimed to gather information regarding the people’s valuation of reduced problems due to environmentally hazardous substances in water (EHSW). The survey was conducted in an area in the southern part of Norway - the Grenlandsfjords area. The change in pollution level caused by EHSW was explained and illustrated as changes in areas of the fjord with restrictions on consumption and sale of fish and shellfish.

John Loomis and Armando Gonzales – Caban, 1994, in their paper on estimating value of reducing fire hazards to old growth forests deal with the results of a mail survey that was carried out in Oregon regarding the WTP of various households for a fire prevention and control programme on northern spotted owl critical habitat units in Oregon. The voter referendum format was used in this study and according to the authors, the CVM may provide a promising avenue for incorporating society's broadening concern about bio-diversity and natural values into public land management agencies fire management decisions.

John Loomis and Armando Gonzales – Caban, 1998, in another paper which is a study on the same lines as the previous one try to calculate the WTP function for protecting acres of spotted owl habitat from fire. Here a CV survey was used to estimate the economic value to California and New England residents of implementing a fire management plan to reduce acres of old growth forests that burn in California and Oregon. According to the authors the acreage of habitat protected can be used as a function by managers to evaluate the incremental benefits of different fire management plans that reduce additional acres burned. These benefits can serve as justification for funding of prescribed fire and fuel reduction programmes to protect critical habitat of the Northern and California Spotted Owl.

Earl R. Ekstrand and John Loomis, 1998, in their paper on estimating WTP for protecting the critical habitat for threatened and endangered fish try to incorporate respondent uncertainty. A comparison of the standard dichotomous choice CV model to alternative modifications that explicitly incorporate respondent uncertainty is performed to estimate economic benefits of protecting critical habitat for nine threatened and endangered fish species living in Colorado, Green and Rio Grande River Basins.

Dominic Moran, 1994, in his study of the Kenyan Protected Areas has attempted to quantify the benefits associated with the non-consumptive use of Kenyan parks and reserves. The figures generated by this study show the magnitude of benefits provision by Kenyan conservation and the proportion of revenue foregone at current pricing rates.

The author insists upon instilling a perception of wildlife as a public resource capable of generating returns to all that who live with it, and not just for private gains.

Charles C. Griffins, et al., 1995, in their paper on connections to new water systems in Kerala, seek to measure the WTP of families in Kerala for household connections to a piped water supply system. Two surveys in 1988 and 1991 were carried out to explore the validity of findings of the first study. In this study major emphasis has been laid on the existing policies and their relevance to the behaviour modelling system.

G.D. Garrods and K.G. Willis, 1997, have tried to capture the recreational value of tropical forests in Malaysia. According to them Forest Recreation Areas (FRAs) in Malaysia are a step towards ensuring sustainable use of the remaining areas of tropical forest. These are provided free of charge to the public. Here the recreational value of these forests has been estimated using CVM. From the results it emerges that the economic benefits of any new FRAs will depend upon value per visit and number of visitors; which will in turn depend upon the substitute sites. However FRAs are seen as having a limited role to play in the conservation of forests since they cover only a small area and their existence is highly dependent upon other economic motives.

Eija Moisseinen, 1989, in the paper on the Siamaa Seal states that attitude causes behaviour, which is actually responsible for the revealed WTP which is the main objective of all CV surveys. But these are usually ignored for they are believed to be outside the scope of economic analysis. This paper studies the effects of the attitudinal responses on a mail survey to assess the WTP of the local population to help conserve the Saimaa Seal which is one of the most endangered seals in the world.

Rosamund Naylor and Mark Drew, 1998, in their paper analyse the use and value of mangroves in Kosrae, Micronesia, where the population is largely dependent on the swamps for fuelwood and other ecosystem services, such as erosion control, storm protection, and nutrient flows to shoreline fisheries. The results indicate that the population places some premium on the existence and indirect ecosystem services of mangroves, over and above the direct use values. The respondents were found to favour a tax system designed to manage and preserve the mangrove's direct and

indirect services over a permit system focussed only the allocation of direct use over time.

Robert Costanza, Stephen C. Farber and Judith Maxwell, 1989, have valued wetland ecosystems and their study involved WTP as well as energy analysis based methodologies. Fundamental theoretical and practical problems underlying natural resource valuation summarise the methods and findings for the study and elaboration on some major problems that arise in applied natural resource valuation. Stress has been laid on the discount rate, which is considered to make the most difference in the final result than any other factor.

Jennifer Pate and John Loomis, 1997, in their paper on wetlands and salmon in California state that most studies do not include variables like distance and the overall area over which the WTP should be aggregated. This study seeks to determine if distance affects `WTP for public goods with large non- use values. The results show without conclusive evidence that there is an indication that WTP does decline as distance increases. For certain goods distance does play a role while not for others. The issue of difficulty of using knowledge in the same model as distance as the level of correlation between the two should be extremely high has also been highlighted. The effect of substitutes on respondents' WTP was also uncovered. The study ultimately came out with the result that restricting benefits to just the political jurisdiction in which the site is located largely underestimates the benefits.

2.6.5 CVM in a Developing Country

Ten years ago only a handful of very rudimentary contingent valuation studies had been conducted in developing countries: at the time the conventional wisdom was that it simply could not be done. The problems associated with posing hypothetical questions to low - income, perhaps illiterate respondents were assumed to be so overwhelming that one should not even try. Today we have come full circle: it is now assumed by many environmental and resource economists and policy analysts working in developing countries that CV surveys are straightforward and easy to do (Whittington, 1998).

Table 2.3 ECONOMIC VALUATION STUDIES – A BIRD'S EYEVIEW

	Resource Type (by the classification)	Resource Kind	Case	Site	Function valued	Value	Unit	Method
1	River	River	W.H.Desvousges V.K.Smith and Ann Fisher 1987	Monongahela river	Option price(recreation)			Contingent valuation
2	National Park	PA	N. Hadker et al 1997	Borivli National park	Recreation Forest,indirect benefits	Rs 20 million/month		WTP,CVM
3	Coastal area	Estuary	S.Goodman et al	British coast	Conservation and Non use			CVM
4	National Park	Park	S.Shultz et al 1998	Poas & Manual Antonio parks, Costa Rica	Biodicersity &National heritage protection			WTP Entrance fees. CVM
5	Tropical Forest		R.T.Carson					CVM
6	Drinking Water	Surface Water	K.Magnussen & O.Bergland	Grenlandsfjords area Norway	Hazardous substances in drinking water			CVM
7	Forest	Forest	J.Loomis & A.G.Caban 1994	Pacific North west Forests	Fire prevention & protection of critical habitats	$77		CVM
8	Forest	Forest	J.Loomis & A.G.Caban 1998	California &New England	Fire prevention & protection of critical habitats	$ 56		WTP
9	River Basin	River	E.R.Ekstrand & J.Loomis 1998	Colorado, Green And Rio Grande river basins	Protecting critical habitats for endangered fish species	$268		WTP
10	Forest	P.A	K.Chopra 1998	Keoladeo National Park India	Biodiversity protection	427.04 432	Rs/visit by Indian Rs./visit foreigner	TCM
11	Forest	P.A	D.Moran 1994	Kenya	Recreation&biodiversity	16-157	USD/Ha	CVM
12	Water systems	Piped water systems	C.C.Griffin etal. 1998	Kerala, India	drinking water supply	700	Rs/connection	CVM
13	Forest	Tropical Forest	G.D.Carrod & K.G.Willis 1997	Malasia	Recreation	1.46	RM/Adult	CVM&TCM
14	Lake	Lake	Eija Moisseinen 1993	Saimaa Lake Finland	Endangered species protection	200-250million	FIM	CVM
15	Forest	Forest	P. M. Fearnside 1996	Rural Amazonia Forest	Biodiversity,water, `carbon	22 1508 21	USD/family/year	
16	Wetland	Wetland	F.W.Bell 1996	South eastern US	Recreational fisheries &asset value	6,471 981	USD.E florida USD. W Fld.	WTP

	Resource Type (by the classification)	Resource Kind	Case	Site	Function valued	Value	Unit	Method
17	Forest	Forest	M.Lockwood J.Loomis T.D.Lacy 1993	South eastern Australia	Logging of native forest	11	/household/year	CVM
18	Forest	Forest	J.Echeverria M.Hanrahan R.Solorzano	Monteverde Cloud forest Costa Rica	Biological resources	2380262	USD/Year	CVM
19	National Park	National park	S.Navrud &E.D.Mungatana 1994	Lake Nakuru National Park Kenya	Recreation	7.5-15 million	USD/Year	CVM
20	Wetland	River wetland	Thibodeu & Ostro 1981.	Charles River wetlands	Recreation	187.74 PV-3,130	USD/Year	WTP
21	Wetland	Swamp	Ghosh & Santra 1995	Wetlands of West Bengal ,India	CommercialAquatic Herbs	600-1,200	USD/Year	Market value
22	Wetland	Mangrove swamp	Naylor & Drew 1998	Kosrae, Micronesia	Mangrove protection and use	a. 0.66-1 b.1 -1.26 (million)	USD/Year	a.Market Value b. WTP
23	Wetland	Coastal wetland	Costanza et al. 1989	Coastal Lousiana	Recreation ,fishing, fur trapping	2429 - 6400	USD/Acre Disc.rate-8%	WTP, Energy Analysis
24	Wetalnd	Coastal wetland	Bergstrom et al. 1990	Coastal Lousiana, US	Recreational	118 27	USD/year	Aggri.Expenditure Consu. surpluse

What Makes a Good CVM Study

1. Only apply CVM to goods with which respondents have at least some familiarity (direct or indirect).

2. Estimates of use value are likely to be more accurate than those for non-use value.

3. The scenario should be understandable and not have a high degree of uncertainty.

4. WTA scenarios should be avoided.

5. The payment vehicle should be realistic and appropriate.

6. The survey should question intentions to behave rather than attitude towards behavior.

7. The scenario should make provision of the good dependent upon behaviour rather than automatic.

8. Adequate, rather than excessive, unbiased information should be provided with the impact of that information assessed via a control group who receive no information.

9. Specific questions should be included to minimise part-whole (mental account) problems.

10. Use both open - ended and dichotomous - choice formats to provide lower and upper valuation boundary estimates.

11. Sample size must be statistically significant.

12. Avoid starting points, bidding games and payment cards.

13. Avoid any direct or implied value cues either via information, questionnaire or interviewer.

14. Choose carefully between face to face to remote (mail, etc.) approaches and ensure you are sampling the correct population.

15. CVM will work best where respondents have some experience of valuing the good in question.

16. In dichotomous choice formats the upper bid level should be such that almost 100% rejection is achieved while the lower bid level should achieve almost 100% acceptance.

17. Analysts should consider carefully the removal of outliers and use of trimmed means.

18. Telling respondents that payments by others will be compulsory may reduce non-response but may increase free-riding and strategic bidding.

19. Great care is required in aggregation process.

20. Theoretical validity tests (bid function estimation) should be carried out.

21. Where possible assess reliability via retesting at a later date.

22. Fully report all results including all sample statistics, details of information given and the full questionnaire reprinted.

There are some contingent valuation researchers that believe that it is easier to administer high-quality contingent valuation surveys in many developing countries than it is in industrialised countries. Response rates are typically very high in developing countries, and respondents are often quite receptive to listening and considering the questions posed. Moreover, interviewers are inexpensive relative to prices in industrialised countries. For a given sample size, the survey costs of an in-person CV survey in developing countries are thus typically an order of magnitude lower than in industrialised countries. This allows CV researchers to use larger sample sizes and conduct more elaborate experimental designs.

2.7 Conclusion

The importance of the valuation context has two obvious implications for CVM. First, the hypothetical nature of CVM may be more of a problem than is generally recognized. As mentioned earlier, where people's values and attitudes are not at a high level of resolution, their responses tend to be more heavily influenced by contextual cues. CVM is used because such goods are not privately purchased. Although the appropriate context is the market, the goods involved are not traded. Because people are not familiar with paying for goods they cannot privately own, they are likely to be particularly susceptible to unintended contextual cues, such as the social acceptability of paying a lot (to create a favourable impression), labels, order effects, and implied constituencies. Moreover, since real life experiences of paying for public rarely exist (not even taxes are paid for specific environmental goods, and taxes are involuntary in any case), people do

not have a well-established context to which to relate, and may therefore be heavily influenced by the artificial context of the evaluation process,

A related problem for CVM flows from the difficulty of accurately specifying the good, Because the type of goods typically evaluated using CVM are not specially valued in monetary terms in real life situations, it is apparently difficult for people to consider these goods in a payment context. As a result, the specific good at times is mistaken for a whole class of goods. An example of this is mentioned by Kahneman (1986) in people's willingness to pay to maintain fishing by cleaning up lakes in Canada. Willingness to pay to clean up the lakes in one region was nearly as large as willingness to pay to clean up the lakes in a whole province containing numerous such regions. It was thus clear that the respondents were apparently providing evidence of their general attitudes about cleaning up lakes for fish,

The other implication for CVM deals with the context of payment. Specifying a payment vehicle may significantly affect bids. For example, people may object to paying outright for something that they value highly, but they consider to be rightfully theirs. They may think that the government should pay for it which suggests that their willingness to pay in taxes would be higher than their willingness to pay outright. (However, they may have biases against taxes). They may also think that industry (for example, in the case of industrial air pollution) should pay, rather than themselves. Furthermore, for nonrival goods in particular, the perceived fairness of the payment vehicle may affect people's willingness to pay. Thus the "payment vehicle " also becomes very important in devising a proper contingent valuation study (Brown and Slovic, 1988).

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CHAPTER III : INTRODUCTION AND OBJECTIVES OF THE STUDY

3.1 Introduction

Water is likely to be the major bone of contention between various nations in the 21st Century. Its alarming depletion and increasing consumption at the global, national and regional levels are soon going to make it one of the most pressing resource issues. Water pollution too adds to the existent problems of local and regional water scarcity by making large amounts of water unfit for consumption. With increasing agricultural, industrial and domestic needs, there is also a growing competition for clean water supplies.

In India, about 200 million people do not have access to safe drinking water. Most of our water sources are polluted with untreated / partially treated wastes from industry, domestic sewage and fertiliser / pesticide run-off from agricultural fields. According to the Ministry of Rural Development, about 1.5 million children die each year due to water related diseases, and the country also loses over 200 million person days of work a year because of these diseases. According to the Ministry of Water Resources, water shortages in India will become even more pervasive by 2025 and stress human and economic development. Appropriate management of water resources is thus crucial for future economic development and protection of human health and life itself (IGIDR, 1999).

The Bhoj Wetland is an important drinking water resource for the citizens of the city of Bhopal. Over the years, because of indiscriminate and unsustainable use, the quality of water in this Wetland has been degraded largely. Moreover with the increasing population of the city and its high growth rate, demand for water for domestic need has also increased manifold. Soon Bhopal City would be in the grip of a major drinking water crisis. Keeping this in view, the objectives of this project gain importance:

1. To value fully the wetland benefits / resources for appropriate allocation of wetland use

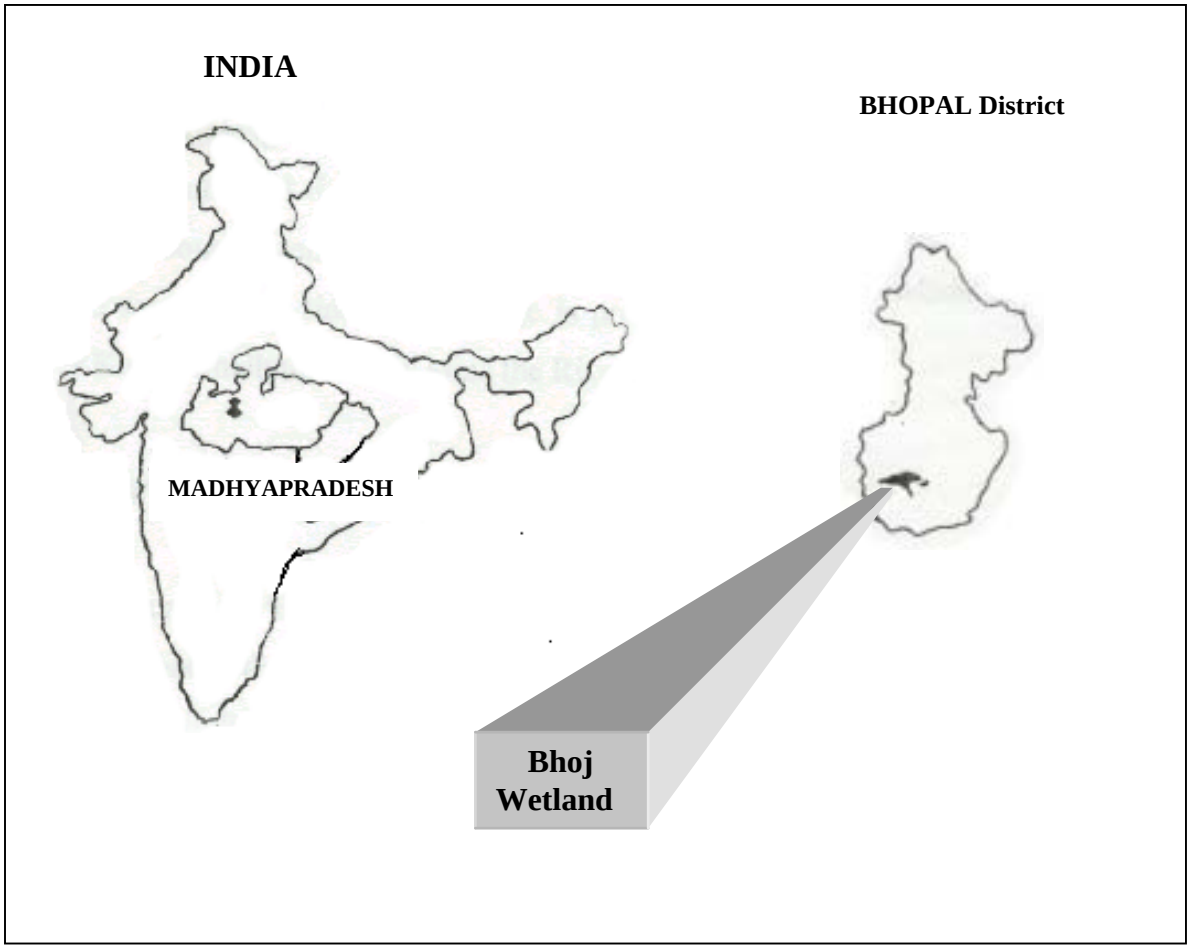
2. Help the planners and policy makers, to develop a socially acceptable, environmentally sound and economically feasible strategy for wetland management.

3.2 Study Area

3.2.1 Location

The Study Area though dealing with the Bhoj Wetland, which consists of the Upper and the Lower Lakes of the City, also concentrates on all the municipal wards falling within the confines of the City of Bhopal. Bhopal is the State Capital of the largest Indian State of Madhya Pradesh lying in the central region of the country. It was declared as the Capital in 1956 and since then it has shown enormous growth not just in area and size but also in the population. The City occupies an area of some 286 sq. km and is divided into 66 administrative wards.

Fig.3.1 Map showing the location of Bhoj Wetland



3.2.2 Physiography

The City lies in a hilly terrain that shows a slope towards north and southeast. Hillocks of different altitudes are situated along the south – west and north – west portion of the city. These hillocks form a continuous belt from Singarcholi to the Vindhyachal range. The maximum height in this region is that of the Singarcholi peak which is 625 m above sea level. The general elevation of the ground level is nearly 460 m along the southeastern and north-eastern portion of the city

Geology wise, the sub-surface in the City area is not rich in minerals. Bhopal stands on red sand stone strata of the Malwa Plateau. The top portions of the various hillocks in the city mainly have hard red soil mixed with boulders. Black cotton soil is however also to be found ranging in depths of 1 to 2.5 m on the north-eastern and south-eastern side of the city.

3.2.3 Drainage

The natural drainage of the city is provided by three main streams, which are joined by a number of small nallahs and rivulets. On the north-eastern side drainage is provided by the river Halali and on the southeastern side by the Kaliasote river. Both these rivers drain into the River Betwa. On the southeastern side the drainage is provided by various small nallahs that drain into the River Kolar, which ultimately joins the River Narmada.

3.2.4 Vegetation

Vegetation around the City is of the mixed forest type. Since the soil is shallow with a sheet of hard red stone bedrock in most places, the growth is stunted. The common trees to be found are *Tamarindus indica*, *Ficus sp*., *Cassia fistula*, *Moringa olifera*, *Cassia seamia*, *Eucalyptus sp*., *Peltoforum sp*., *Mangifera indica*, *Jambolina indica*, *Grevillea robusta*, *Cassurina equatifolia*, *Madhuca indica*, *Pongamia sp*., *Acacia sp*., *Prosopis juliflora*, *Schlericha oleosa* and many others.

3.2.5 Climate

The city enjoys a moderate climate. Normally temperature ranges between 9^0 C and 42^0 C. In the hottest month of May mean daily maximum and minimum temperatures of 41^0 C and 27^0 C can be experienced along with hot and scorching atmosphere and dust – laden winds. In the months of December and January the mean daily maximum and minimum temperatures fall to 25^0 C and 10^0 C respectively. The relative humidity in Bhopal varies from about 20 per cent to 90 per cent. The average annual rainfall in the city amounts to nearly 1150 mm. There is a seasonal variation in wind direction. In Bhopal, during summer and monsoon seasons the winds are generally from west and northwest whereas during the winter months the winds blow from north and north east directions. Wind speeds are in the order of 4 to 6 km/hour during the winter months but increase to about 7 to 13 km/hour during the remaining months. Wind wise, the mornings are usually calm but afternoons become gusty. Variations in direction and speed of wind are also produced because of the numerous hills and valleys situated in and around the city.

3.3 History of the Bhoj Wetland

The Bhoj Wetland comprises two lakes the Upper and Lower Lakes. Out of these the Upper Lake is older and has a very rich history. Raja Bhoj, the famous Parmar king is credited with the creation of this lake and thus the Wetland too and in fact the city of Bhopal too is named after him. The present lake is only a small part of a vast lake that was created by Raja Bhoj in the 11^{th} century (1000 ~ 1055 A.D.). Archaeological and historical evidences support the existence of a huge lake in the area at that time. According to a legend, also quoted by the historian

> The Bhopal lakes are very famous and a number of verses have immortalised these. One of the most quoted ones is as follows:
>
> "Tal to Bhopal tal aur sab talaiya
> Rani to Kamlapati aur sab ranaiya
> Garh to Chittaurgarh aur sab garhaiya
> Raja to Ramachandra aur sab rajaiya."
>
> ("If there is a lake, it is the Bhopal tal, and all others are but small ponds / If there is a queen she is Kamalapati and all others are minor queens / If there is a fort it is Chittaurgarh, all the rest are fortresses / If there is a king, he is Ramachandra, all others are petty chiefs.")

and archaeologist W Kincaid, Raja Bhoj was stricken with a severe skin disease akin to leprosy, which his court physicians failed to cure. A holy recluse prophesied that the king would die of the disease, unless he was able to construct a lake that would be the largest in India, and fed by 365 streams.

Skilled engineers were then sent along the valleys of the Vindhyan range to explore the region and report upon the feasibility of such a lake being constructed. A valley was ultimately discovered and subsequently enclosed, which included the headwaters of the river Betwa. But the engineers found, much to their disappointment, that only 356 springs and streams fed the valley. The difficulty was eventually overcome by Kalia, a Gond chief, who pointed out a missing river which, with its tributaries, made up the requisite number and was accordingly named Kaliasot or Kalia's river, a name that it carries to this day.

A study of the local topography and the remains of the civil works, in Kincaid's analysis, clearly proves that the engineers of those days skilfully turned the waters of another river, which rises 32 km to the west, into the Betwa valley. This was accomplished by creating a magnificent, cyclopean dam in Bhopal. From the storage lake thus obtained, a river flowed at a right angle to its former course; it became a valuable feeder. The Kaliasot River carried its surplus waters into the larger lake for three full months after the rainy season had ended. This ancient lake covered an area of 65,000 ha. It must have at that time formed the largest artificial lake in the Indian peninsula – one unbroken sheet of water with islands adding to its beauty. It was in places, more than 30 metres deep, and was surrounded by high hills on all sides.

The waste weir cuts through the solid rock of one of the lower hills. It is situated at the apex of a triangular valley, and is probably 3 km from the great dam in a direct line. Its position, so far from the dam, according to Kincaid provides further proof of the practical ability of the engineers of the time. Any error in levels would have quickly destroyed the dam which, though stone-faced on both sides, was filled in by earth and could not have withstood heavy overflows for long. The second *bund* was thrown across the only other

opening of the valley, which turned the Kaliasote off its course at right angles into the Betwa.

This vast expanse of water was later destroyed by Hoshangshah of Malwa (1405 – 1435 A.D.) whose army cut across the lesser dam and thus emptied the lake. The evidence of destruction of the embankment can still be seen at a place called Mendua, not very far from the Shiva Temple at Bhojpur. According to the Gond folklore, it is said that it took the army three months to cut through the dam and the lake took three months to empty and the thick fertile black sediments left behind were not habitable for the next thirty years. The dam across the Betwa was also destroyed by the armies of Hoshang Shah. The embankment at Bhopal is till preserved at Kamla Park and so is the lake known now as Upper Lake but in a much constricted size (Dying Wisdom, 1997).

After the decline of the Parmar power the town remained ruined for almost 600 years. The area, however, was under the control of rulers of Malwa and later on under the Emperor of Delhi. After Akbar's rule, the area passed to the control of local tribal chieftains and Gond kings who incessantly fought until Dost Mohammad, one of the army chiefs of the Mughal army established his firm rule by the first decade of the 18th century. In 1794, Nawab Chhoten Khan, the Minister of Nawab Hiyat Mohammad built a 300 yards long and 23 yards wide solid masonry dam across Banganga forming the Lower Lake. (Dying Wisdom,CSE,1997)

Bhopal as a city has been growing rapidly especially in the last few decades. There has been a lot of migration into the city from the other parts of the country to provide the work force for the Bharat Heavy Electricals Limited, a large public sector unit situated here. To provide for the needs of this work force other people moved in to begin several businesses and all and since then the city has been constantly swelling in size. The population change in the city in the last hundred years are as given below:

Table.3.1 Changes in Population of Bhopal

Year	Population	Change in population	% age growth
1901	77023		
1911	56204	-22819	-27.04
1921	45094	-11110	-10.77
1931	61037	+15943	+35.35
1941	75228	+14191	+23.25
1951	102333	+27105	+36.04
1961	185374	+83041	+81.17
1971	298022	+112648	+60.77
1981	672329	+374307	+125.60
1991	1063662	+391333	+58.21
2001*	1500000	+436338	+41.02

* As projected
Source: Census, 1991

As per the increasing population demands, there have also been significant changes in the land use patterns of the city.

The city has been growing as represented by the following maps in the years as specified.

3.4 Status of The Bhoj Wetland

The Ministry of Environment & Forests (MoEF) of the Government of India has declared the Upper and the Lower Lake to be a Wetland of National Importance in the year 1988. Bhoj Wetland is one of the sixteen wetlands in the country that have been so far identified for conservation and management.

3.4.1 Upper Lake

The Upper Lake as mentioned above is the highly diminished remains of the large lake constructed by Raja Bhoj, in the 11th century. The seasonal river Kolans, originating from Sehore, some forty eight kilometres from Bhopal, and several small feeder streams at the western side of the lake, form the source. The lake is dammed at two places: 1) On its eastern end near Kamla Park where there is a permanent underflow outlet into Lower Lake, 2) In the southern part at Bhadbhada, where there are eleven sluice gates to let out the excess water from the lake into a channel, which then carries the excess

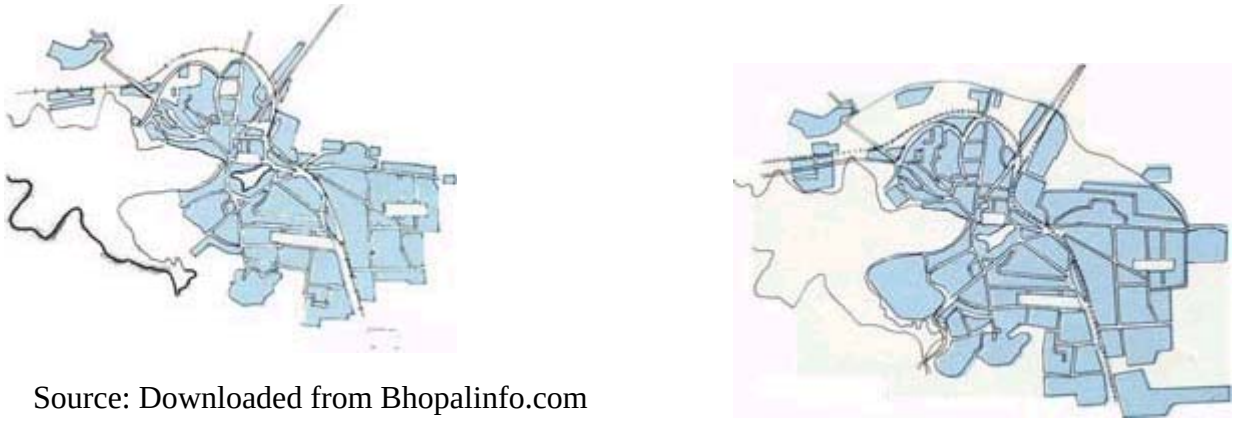
water into the Kaliasot river. The Upper Lake has a catchment area of 361 km ^{2} and a waterspread area of 31 km^2.

Fig.3.2 Maps of the Bhopal City (habitation area in blue, partial boundary of lake shown in black in the west of the city) since the formation of the Upper Lake one thousand years back

1010 - 1200 AD 1201-1800 AD 1801-1850 AD 1891-1930 AD

1931-1950 AD

1973-1981 AD 1981-1991 AD



Source: Downloaded from Bhopalinfo.com

3.4.2 Lower Lake

The Lower Lake also known as the Chotta Talab or Small Lake, is situated towards the east end of the Upper Lake and is almost fully surrounded by built-up areas. It has a small catchment area of 9.60 km^2 and a water spread area of 1.29 km^2. Lower Lake receives its inflow in the form of seepage from the Upper Lake in addition to the drainage coming from 8 nallahs or drains. Water level is maintained constant by regular outflow through a waste weir at Pul-Pukhta into Patra Nallah.

The salient features of the Upper and the Lower Lake of Bhopal are presented in Table 3.2

Table 3.2: Salient features of the Upper and Lower Lakes of Bhopal

Sl. No.	Item	Upper Lake	Lower Lake
1	Constructed in	11th century	Late 18th century
2.	Type of Dam	Earthen dam	Earthen dam
3.	Location: Longitude Latitude	$77^0$18' ~ $77^0$24' $23^0$13'~ $23^0$16'	$77^0$24' ~ $77^0$26' $23^0$14'30" ~ $23^0$15'30"
4.	Catchment area km^2 (sq. miles)	361 (141)	9.6
5.	Submergence area at FTL / water spread area km^2 (sq. miles)	30.72 (13.9)	0.90
6.	Maximum water level RL m (ft)	508.65 (1666.80)	
7.	Dead storage level RL m (ft)	503.53 (1652.00)	499.88
8.	Storage capacity 10^6 m^3 (mft^3)	101.6 (3588)	8 (282.5)
9.	Deepest bed level RL m (ft)	499.26 (1638.00)	
10.	Maximum depth m (ft)	11.7 (38.4)	9.4
11.	Mean depth m (ft)	6.0 (19.7)	
12.	Total length of weir m (ft)	102.1 (335)	
13.	Crest level of spillway RL m (ft)	504.38 (1654.80)	
14.	Designed flood discharge m3/sec	2208	
15.	Moderate flood discharge m3/sec	538.02	
16.	Sewage water inflow m3/day (MGD)	33080 (7.3)	--

Sl. No.	Item	Upper Lake	Lower Lake
17.	Sources of water	Rain water	Rain water, Seepage from Upper Lake, and domestic sewage
18.	Main use of water	Potable water	Washing clothes, recreation

Source: SAPROF Report, 1994

FTL – Full Tank Level., MGD – Million Gallon per Day., ft – Feet., m^3 – cubic meter., Km^2 –Square Kilo meter

3.4.3 Socio-economic Details of the Catchment Area

It has been found that there are some 8259 huts and houses in the catchment area of the Upper Lake. The total population in the area amounts to nearly 44,166. Sixty seven per cent of this population in the area use open land as lavatory. Everyday some 2000 persons use the lake waters for bathing, washing clothes and cleaning vehicles. All these people use soap and detergent that directly enters the lake waters. Some 15,000 domestic animals such as buffaloes, cows, oxen, pigs, goats, etc. are to be found in the catchment area. 2485 hectares of land is used for agriculture and 692 as pastureland for grazing animals. The farmers usually grow two crops in a year of wheat, rice, jowar, makka, pulses, gram, vegetables, etc. For all these crops fertilisers like Urea, Growmore, Compost, etc. are used. Few farmers also use herbicides and pesticides. Most of the agriculture residues find their way into the Upper Lake as run-off. (Environmental Status Report of Upper Lake, Bhoj Wetland, Bhopal)

Plate.3.1 Pumping Station at Kamala Park (U.L)

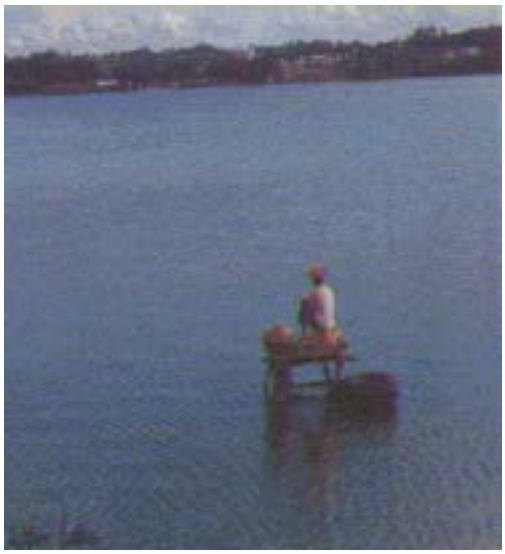


Plate 3.2 : Fishing activities in Upper lake

Plate 3.4 : Siltation Point at Upper Lake

Plate : 3.5 Trapa cultivation at Upper Lake

Plate 3.8 Weed infestation in the Upper lake

3.5 Uses of the Bhoj Wetland

i) **Drinking Water –** Nearly half of the city's drinking water supply comes from the Upper Lake and this is the most important use of the wetland as far as the welfare of the citizens is concerned. Till 1947, the water was used without any means of filtration, which means that the water quality was very good. But in the recent years, the quality of water has greatly deteriorated. Altogether some 28 MGD of water is provided to the city of Bhopal from the Upper Lake.

ii) **Employment** - The Bhoj Wetland provides employment to various communities like the fishermen, washermen, boatmen, vendors and so on. Approximately, 300 families arengaged in fishing and *trapa* cultivation while some 100 washermen also make their living from the Wetland. There are some 50 boatmen whose livelihood is dependent upon the Bhoj Wetland. Because of the many visitors to the lake, a number of roadside vendors selling maize cobs, and other food items and snacks, have their stalls next to the lakes and earn quite significant amounts.

iii) **Microclimate stability** - The microclimate of Bhopal is quite moderate as compared to the surrounding areas. The city according to its geographical location should actually have an extreme type of climate, but owing to the proximity of the Wetland, moderating effects on temperature and again cool land breeze during the evenings can be experienced which makes the evenings even during the peak of summer very enjoyable. Off course the moderating effects are also influenced by other factors such as the vegetative cover and all but the effect can be largely attributed to the Wetland.

iv) **Recreation:** The Bhoj Wetland provides ample recreational opportunities to the people of Bhopal. There are parks and fountains as well as boating consisting of paddle and rowing boats. Some time back motor boats were also being run but were stopped since they were adding to the pollution and disturbing the migratory birds that arrive National Park, which is situated at the southwestern border of the Upper Lake. This too houses many species of animals and is a major attraction for families and children mainly.

The above are the major direct and indirect use values of the Bhoj Wetland. Other usual wetland benefits like irrigation, ground water recharge and maintenance of biodiversity are not all that important mainly because of the following – direct irrigation from the lake is not allowed; there is no proof of ground water recharge as direct connections between the aquifers has not been established; being a man made reservoir to be used mainly as a drinking water source there are no endangered or unique species as such to be found in the Wetland.

3.6 Threats to the Wetland

Being an urban wetland, the Bhoj Wetland is in fact more fragile as the level of human interference is very high. The threats to the Wetland have mainly been identified as:

Siltation - This is a major threat to the wetland. The silting rate is estimated to be about 1 cm to 2.58 cm per year on an average. The estimated sedimentation rate from the catchment area is in the tune of 3.67 ha.m/100 km^2/ year (SAPROF Report, 1994).

Because of this the storage capacity of the lake is greatly reduced and besides shrinking of the shorelines and creation of silt islands takes place.

Solid waste pollutants - The Wetland is slowly being choked by this menace, especially polythene carry bags, since quite a lot of the city's waste finds its way into the Lakes in spite of there being a waste collection and disposal system being managed by the Bhopal Municipal Commission. This has lead to wide spread contamination of the Wetland.

Sewerage - It has been estimated that nearly 7,500 m^3/ day of sewage water and 360 m^3/day of animal liquid discharge join the Upper Lake which is a source of drinking water. Altogether 11 inlets enter the Bhoj Wetland carrying with them sewage and silt. As yet the city of Bhopal does not have a proper sewage system.

Washermen - The Lower Lake has been traditionally used by the washermen community for washing of clothes. This leads to input of high quantity of detergents, chemicals and furnace ashes into the Lake on a daily basis. As a result the water quality of the Lower Lake has deteriorated greatly.

Trapa cultivators - *Trapa* is quite popular among the people of Bhopal but since the cultivation is carried out in the major drinking source it leads to contamination and also addition of biomass to the Wetland. It also leads to gradual conversion of the Wetland into landmass.

Encroachment - Encroachment by urban slum dwellers and also in the form of agricultural invasions is very rampant along the fringe areas of the Wetland. This is creating pressures of many sorts on the Wetland in the form of pollution through human excreta and agricultural residues and wastes, besides decreasing the area of the Wetland.

Increasing population - The City is growing at a rate that is quite alarming. Because of this the Wetland is under a lot of stress since it has to provide for the city's population needs of drinking water, fish requirements and also space. Besides, it serves as a sink for all the sewage and some of the solid waste.

Weeds and eutrophication - The Upper and the Lower Lakes are largely weed infested and the spread of weeds is over a large area of infested fringe area) nearly. The weeds to be found are mainly of three types: Shoreline (Rooted) – *Trapa bispinosa, Nelumbium sp*.; Emergent – *Ipomoea aquatica, Polygonum glabrum*; Floating – *Eichhornia crassipes, Lemna minor*; and Submerged – *Potamogeton sp., Chara sp. Hydrilla verticillata*, etc. The weeds have been quantified as follows:

Table 3.3 Area of Wetland under weeds

	Shoreline (Rooted)	Emergent	Floating	Submerged
Infested Area (sq. km)	5.219	4.728	0.35	23.483

SAPROF Report, 1994

Boating - Motor boats plying in the Lakes leads to pollution of several kinds like oil, grease and smoke. Besides, they also disturb birds, which visit the Wetland during the winter months. As a result motor boating has been stopped in the area. Paddle and row boats of Tourist Department and private agents are functioning in the lake

Agricultural waste - A lot of agricultural land surrounds the Bhoj Wetland as the city of Bhopal lies on the eastern side of the Wetland mainly. Also most of the catchment area consists of agricultural land as well. Because of this all the fertilisers and pesticides and agricultural residues used in the fields find their way as run off into the Lake waters leading to major and dangerous contamination, both to flora, fauna and human life.

Idol and tadjia immersion - During the Hindu and Muslim religious festivals, lots of idols and *tadjias* are immersed in water. This leads to siltation on quite a large scale besides releasing heavy metals like cadmium, chromium, lead zinc and other extremely harmful chemicals, and also harbouring bacteria in the biodegradable matter.

Hospital Waste - Some of the major hospitals of the city were disposing their waste directly into the Lakes. This waste mainly consisted of infected and soiled bandages, used medicines, syringes and injection bottles, This kind of contamination could easily lead to the outbreak of epidemics in the city. Incinerators have now been established in the medical college but other smaller hospitals and private nursing homes are still carrying on with this system.

3.6 Concluding Remarks : What the Future Holds for Bhoj Wetland?

Despite multiple direct and indirect benefits from the Bhoj Wetland, the very existence of the wetland is threatened due to excessive pressure in the form of threats from various anthropogenic activities in and around the lake. To control such pressures a two way strategy following both the defensive and preventive techniques needs to be implemented on a war footing manner. People also need to be made aware of such threats and need to be involved in the management and restoration activities. If such things do not happen in near future it would be difficult to save this pristine wetland and it shall have the same fate as many other urban lakes in India.

CHAPTER IV : METHODOLOGY FOR ECONOMIC VALUATION OF BENEFITS FROM THE BHOJ WETLAND AND THEIR SUSTAINABLE MANAGEMENT

4.1 Introduction

This chapter provides an overall assessment framework for the economic valuation of Bhoj Wetland, which is later on used to illustrate the role of economic valuation in the Bhoj Wetland management decisions. It contains the various efforts that were put in to carrying out the exercise with the detailed methodology of valuation techniques beginning with more straight forward use of market price data, together with information about existing productivity stemming from the wetland. Health impacts due to falling water quality are studied through cost of illness and preventive cost approach. Contingent valuation, which involves the direct measurement of willingness to pay values is also well represented. Hedonic pricing is adopted to see the impact of the existence of Upper Lake on property prices. Then for suggesting future management strategies sophisticated techniques, such as the integrated Modelling of hydrological and economic system are presented through ecosystem Modelling for the assessment of complex ecological functions and changes in the land use due to anthropogenic pressures.

4.2 Project Methodology

The aim of the project as mentioned before is mainly to calculate the economic values of the Bhoj Wetland, which is being treated as a natural resource here. For this purpose, a number of activities had been undertaken during the course of the project period. The project methodology that had been adopted is as follows:

1. **Literature Review:** This provides the backbone for any project and accordingly it was given the required importance in this study too. Nearly six months were spent on extensive literature review, which provided clarity not just with regard to implementation of the valuation techniques but also in the problems particular to the Bhoj Wetland, due to its urban status.

2. **Site Visits:** These were carried out to gather first hand knowledge and view about the existing system and the activities which are being carried out near the Wetland system. Identifying the stakeholders also became possible because of this.

3. **Focussed Group Discussions:** After identifying the various stakeholder groups, focussed group discussions were held with the concerned parties in order to obtain their view regarding the status, use and threats to the fragile ecosystem.

4. **Secondary Data Collection:** Secondary data regarding the pollution status, meteorological and climatic data, revenue and expenditure was collected from various sources like government offices, project authorities and so on.

5. **Workshops:** Workshops involving the various stakeholders and cutting across ranks and positions were held to gain insight into the use and management problems as well as conflicts arising at various levels (details in Annexure - III). Besides, a meeting of experts was also held to discuss and finalise the questionnaire to be used for the Contingent Valuation Method.

6. **Survey:** A household survey of some 1500 households was conducted to arrive at the willingness-of-people to pay for improved recreational benefits from the Wetland. The method used was the Contingent Valuation Method.

7. **Consultations:** Consultations were held with a number of international & national experts regarding the methodology to be followed and the data analysis in order to arrive at better results.

8. **Data Analysis:** Finally, the data collected in the course of the project duration was analysed thoroughly using various economic and statistical tests and the results were arrived at and compiled in the form of a project report.

4.3 Economic Valuation of Natural Resources

According to Kenneth E. Boulding, primitive men, and those of the early civilisations imagined themselves to be living on a virtually illimitable plane. Gradually, however, man has been accustoming himself to the notion of the spherical earth and a closed

sphere of human activity. It was only in the fifteenth and sixteenth centuries, that through circumnavigation and geographical explorations, the fact that the earth was a sphere became widely known and accepted. Economists though have found it difficult to come to grips with the ultimate consequences of the transition from the open to the closed earth. "The closed earth of the future requires economic principles which are somewhat different from those of the open earth of the past. For the sake of picturesqueness, I am tempted to call the open economy the "cowboy economy," the cowboy being symbolic of the illimitable plains and also associated with recklessness, exploitative, romantic, and violent behaviour, which is characteristics of open societies. The closed economy of the future might similarly be called the "spaceman" economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy. The difference between the two types of economy becomes most apparent in the attitude towards consumption. In the cowboy economy, consumption is regarded as a good thing and production likewise; and the of the economy is measured by the amount of the throughput from the "factors of production," a part of which, at any rate, is extracted from the reservoirs of raw materials and noneconomic objects, and another part of which is output into the reservoirs of pollution. If there are infinite reservoirs from which material can be obtained and into which effluvia can be deposited, then the throughout is at least a plausible measure of the success of the economy. By contrast, in the spaceman economy, throughout is by no means a desideratum, and is indeed to be regarded as something to be minimised rather than maximised. The essential measure of the success of the economy is not production and consumption at all, but the nature, extent, quality, and complexity of the total capital stock, including in this the state of the human bodies and minds included in the system. In the spaceman economy, what we are primarily concerned with is stock maintenance, and any technological change which results in the maintenance of a given total stock with a lessened throughput (that is, less production and consumption) is clearly a gain (Earthscan Reader: The Coming Spaceship Earth).

Following this consideration of the earth as “Spaceship Earth”, natural resources are thus classified into exhaustible and renewable resources. Exhaustible resources such as petroleum, coal and metals are those, the stock for which is fixed. Use of exhaustible resources depletes the current stock of the resource, reducing its future availability. On the other hand renewable resources like soil, water, crops, fish, wildlife, forests and solar energy are regenerated through natural growth though the time and space of regeneration may greatly vary. Renewable resources typically have multiple uses. Because of their dependence on complex physical, biological and chemical processes, and the multiplicity of uses, renewable resources are generally more difficult to manage than exhaustible resources (Prato, T., 1998). Thus it becomes necessary to make a suitable action plan for the sustainable management of these resources for future use keeping in mind the changing use and demand patterns.

Sustainable development too, involves maximising the net benefits of economic development, subject to maintaining the services and quality of economic development, subject to maintaining the services and quality of natural resources over time. Sustainable development is possible only when the following factors are taken care of:

a) Utilise renewable resources at rates less than or equal to the natural rate at which they can regenerate.

b) Optimise the efficiency with which non-renewable resources are used, subject to substitutability between resources and technological progress. (Pearce and Turner, 1990)

Natural resources such as forests and commercially exploitable fisheries and environmental attributes such as air quality are valuable assets in that they yield flows of services to people. Public policies and the actions of individuals and firms can lead to changes in the flows of these services; thereby creating benefits and costs. Because of externalities and the common property and public good status of at least some of these services, market forces can be relied on neither to guide them to their most highly valued uses nor to reveal prices that reflect their true social values. It is the failure of the market system to allocate and price resource and

environmental services correctly that creates the need for economic measures of values to guide policymaking.

The economic value of a resource –environmental system as an asset can be defined as the sum of the discounted present values of the flows of all of the services (Freeman, 1993). In other words, it means putting a money value on the benefits and flows of services that are obtained from any system. This idea of monetising benefits or damages to the environment is not easily acceptable to people. But the justification for monetary valuation lies in the way in which money is used as a *measuring rod* to indicate gains and losses in utility or welfare. The reason why money is used as the measuring rod is that all of us express our preferences every day in terms of these units – when buying goods we indicate our 'willingness to pay' (WTP) by exchanging money for the goods, and, in turn, our WTP must reflect our preferences. Economic values have many uses: they help us to identify, or at least approximate, the optimum. Another use is to demonstrate the *importance* of environmental policy. The gains or benefits from environmental benefits tend to be found more in the quality of life than in any increment to a nation's economic output. Thus since they are less 'concrete', more 'soft' than market-place benefits. As a result they are downgraded in comparison (Pearce and Turner, 1990).

Total Economic Valuation is actually composed of a number of values that are broken up mainly into use and non-use values. The use values are mainly direct and indirect use values. Other than this option values and existence values also form part of the total economic value studies. But this total economic value can still not be considered to have captured all the values that are actually present in the system, since only economic values are captured. Some *intrinsic* values still remain. Secondly, many ecologists say that total economic value does not give the entire economic picture either. There are a number of underlying functions of ecological systems called as primary values upon which all the ecological functions are contingent. Some of these functions are not covered by the concept of total economic valuation (Pearce, 1995). Thus at times, a valuation exercise may not reflect all the values of the system under consideration, but in the Indian context, it is more important to stress on the concept of total economic valuation rather than

whether the value thus calculated is complete or not. The methodological issues can be considered once there are some valuation exercises to serve as a basis.

4.4 Methodology

The major valuation techniques dealt with in this exercise are direct valuation including production function and indirect valuation approaches like cost of illness approach, cost of avoidance, contingent valuation and hedonic pricing. It is tried to capture the major use values of the wetland ecosystem and it is believed that a number of indirect uses are embedded in the system and thus have also been captured simultaneously.

The methodology for valuation of the uses, that has been followed is as:

1. **Direct Valuation** – The lake produces many direct benefits like drinking water, fish, trapa, recreational activities like boating. The monetary value of the major benefits and the income generation these activities has been calculated by taking into account the number of people who make their living therein as well as the amount that they earn on an average in a year taking seasonality into account. The various people thus covered are fishermen, private boatmen, washermen or *dhobis*, *Trapa* or *singhara* cultivators, vendors on the lake sides and so on. Besides these, value of supplying water to the people and the water tax that is being charged from them is also taken into account. Also the revenue generated by the Madhya Pradesh Tourism Department through its boating activities and the cafeteria run by it are considered. All this data was collected through secondary sources, focussed group discussions with the various stakeholders as well as through primary survey.

2. **Cost of Illness Approach and Defensive or Preventive Costs** – The water quality in the Upper and the Lower Lakes has deteriorated largely and that too mainly over the last couple of decades. The reasons for this can be attributed to the growing sewage discharge into the lakes and other forms of anthropogenic pressures that exist in the vicinity. As a result there are numerous incidences of the outbreak of water borne diseases in the city. In this exercise the figures of such cases in the last four years of a few water

borne diseases have been collected from the government hospitals. The average expenditure that occurs in these cases have then been calculated and thus the total costs spent on an average on these has been obtained. The cost of man-days lost on account of these illnesses is also taken into account. Moreover, people also resort to a number of preventive measures to protect themselves against these diseases like installation of water purification devices and vaccination against Hepatitis B. The expenditure that is made on such measures has also been used to obtain the willingness of people to pay for clean water and the kind of importance given by them to water quality.

3. **Contingent Valuation Method (CVM)** – When relevant market behaviour is not observable, the contingent valuation method puts direct questions to individuals to determine how much they might be willing to pay for an environmental resource, or how much compensation they would be willing to accept if they were deprived of the same resource. The contingent valuation method is more effective when the respondents are familiar with the environmental good or service (for example water quality) and have adequate information on which to base their preferences (Munasinghe and McNeely, 1994). {Details about the CVM have been given in the Part I, of the report}

Sampling plan: Altogether 1500 households over the entire city were sampled under this study. The sampling methodology adopted was as follows: The city of Bhopal – the Universe for this study, comprises of 66 municipal wards. A population wise representative sample from each ward was taken. To decide the sample size from each ward the population of the ward divided by the 1991 population of the entire city gave the fraction of people to be interviewed from the ward. This fraction formed the percentage of interviews in a particular ward of the total sample. Eventually 1504 households were interviewed in this study. (details in Annexure I) From each ward once more the various colonies or habitation areas were identified and the number of samples to be interviewed from each of these areas was calculated on basis of the number of houses there. Finally at the time of survey, the samples were identified on a random basis keeping the households interviewed at appropriate distances so as to cover the entire locality. Thus the sampling pattern that is used is a three stage purposive sampling method. The first stage is the selection of all the wards. Next is

the selection of major population habitats in the area. The third is the random selection of households from these colonies. Since the third stage is actually an example of quota sampling, the whole sampling design can be called as a three stage purposive sampling plan.

Questionnaire and Scenario build-up: CVM in this study has been used to capture mainly the recreational benefits that the citizens of the city derive from the Upper and the Lower Lake. After detailed discussions with experts and others, it was found that capturing the recreational and aesthetic values would also have embedded within it the existence and the bequest values. The CVM is used only for recreational and aesthetic benefits since the other benefits do not extend to the entire city. Moreover, there are no rare species to be found in the Wetland because of which biodiversity conservation in this case no longer remains important. A detailed questionnaire was used to elicit the Willingness to pay of the people for increased recreational and aesthetic benefits from the lakes (attached in Annexure – II). A scenario explaining the benefits of the lakes and the kind of possible recreational improvements that can be made was presented before each householder through photographs, and information shared with the people. The householders were then asked to state how much they would be willing to pay in order to enjoy the increased benefits from the lakes and also how much they would contribute as tax whereby the entire collections made thereof would go towards the maintenance and provision of recreational benefits. The median figures for these were then taken into account and extrapolated for the entire city. For the scenario build-up to be presented before the people, a detailed ecological modelling exercise was carried out to provide a basis for scenario buildup. The details of these are given in Chapter – V.

Hedonic Pricing - Often, relevant market data to value environmental resources are not available in a directly usable form. In such cases, analysis of indirect market data using, for instance, statistical and econometric methods permits the valuation to be carried out implicitly (Munasinghe and McNeely, 1994). In areas where relatively competitive markets exist for land, it is possible to decompose real estate prices into components attributable to different characteristics such as proximity to schools, shops and parks, and so forth (Cropper and Oates, 1992). To value an environmental amenity like proximity to the Lakes in this case, the method seeks to

determine that component of the property value attributable to the relevant environmental variable. Thus the marginal willingness to pay for improved local environmental quality is reflected in the increased price of housing in cleaner neighbourhoods (Munasinghe and McNeely, 1994).

The method followed in this study considered the rates of property in various parts of the city. These properties were then analysed on the basis of their locational and neighbourhood advantages, proximity to markets, accessibility on basis of distances from downtown and environmental factors like pollution levels and also whether the lake was present in the vicinity or not. Regression equations were then run on these to obtain the marginal willingness to pay of the people for housing in locations close to the Lakes.

4.4.1 Ecosystem Modelling of Bhoj Wetland Using Water Quality Parameters

Economic value of any water body, whether used for potable water supply or aquaculture depends upon its water quality. Better the quality better will be the economic value. People pay more for better quality. Through this WTP survey the aesthetic value of Bhoj wetland is estimated. The present situation of the lakes is very complicated due to the various ongoing restoration activities. More over in the survey it was necessary to present the overall picture of the water body with changes occurred through years due to various anthropogenic activities. These changes on the water quality and its impact were the main concern in the pre test of the WTP questionnaire. People in the pre-test were unaware about the ongoing restoration activities and doubtful on its end results because the changes in the water quality due to the restoration activities are less observable in the limited period of time. And the same time people were asked to pay for the restored and well-managed lake for its recreational aspect. So it came necessary to project the scenario after the restoration. The model can show the scenario of the wetland for the next 25 years . The policy makers can utilise these results to adopt suitable management activities in the restoration process.

The first pre- restoration model clearly shows the importance of restoration of the wetland. in the second model ,i.e. model for ongoing restoration finds changes in water quality. This was very useful to explain the situation after the restoration to the

people. People were always ready to pay more if the goal has achieved i.e, for better aesthetic conditions of the wetland.

The model results are useful to explain the problem of pollution and management strategies. The proposed lake management society can make pollution mitigation policies according to this model results. People expressed their willingness to pay for such society.

As mentioned earlier that the major function of the Bhoj Wetland specially the upper lake is to provide drinking water to nearly 40% of cities population. There are other competing uses like fishing, recreation (which can be permitted on limited basis) but uses like washing, bathing and immersion of ideals; agricultural run off, sewage disposal are severely deteriorating Bhoj Wetland's water quality. The water quality of the upper lake was in 'A' class till 1947 (the water quality standards are mentioned in Chapter V on Ecosystem Modelling). Since then there has been considerable deterioration in the water quality and now it is in category, 'C' class for designated use and that of lower lake is in category 'E' for designated use. As there are interventions now in the form of restoration activities by the State Government, in the planning of the project the target level of water quality in the two lakes have been established as per the tolerance limits and are set as class 'A' in the case of upper lake and class 'D' in the case of lower lake.

Basic ecological parameters relating to water quality like Dissolved Oxygen, Biochemical Oxygen Demand, pH, Total Hardness, Total Alkalinity, Phosphate, Turbidity, Total Dissolved Solids and Bacterial count are taken into consideration and their linkages and changing values due to increasing anthropogenic pressures have been studied. Taking these parameters, a system's model using STELLA software has been developed to understand the dynamics of Bhoj Wetland Ecosystem. Over time data pertaining to various parameters mentioned above is used to determine the trend in the lakes ecology. Various scenario runs are performed to see the future of the lake before and after the restoration activities. Through simulation runs the policy interventions are suggested such that the actions can be prioritised and lake could be maintained in a sustainable manner. Else it would have the same plight as the other lakes in different cities of India.

CHAPTER V : ECOSYSTEM MODELLING OF BHOJ WETLAND USING WATER QUALITY PARAMETERS

5.1 Introduction

As mentioned in the methodology section, the main objective of Ecosystem Modelling of Bhoj Wetland using water quality parameters is to first study the current status of the lake, changes in the water quality parameters over the past years and then based on the past data and the ongoing restoration activities to project the status of two lakes in future. This shall help to provide an insight for sustainable management techniques through prioritisation of various interventions and undertaking restoration activity. The threats to BWL have been dealt in details in chapter III. This chapter begins with the general introduction to Ecosystem Modelling and then discusses model for the Bhoj Wetland using water quality parameters. Further it gives an account of ongoing restoration activities taken up by the Bhoj Wetland restoration project executed by the Environmental Planning and Co-ordination Organisation (EPCO). It then gives values of the parameters at different points of time and their current status at seven Quality Monitoring Stations at upper and Lower Lakes. Using the data pertaining to these parameters an advanced ecological model is developed using software called as STELLA. Based on 1985, 1991-92 and 1999 data pertaining to these parameters compound growth rates are determined and elasticity between various variables are worked out so as to establish the linkages between them. Having established significant linkages, the model has been developed and simulation runs are performed first by using 1985 and 1991-92 data to find out what could be the status of the lake if such trends continued (without restoration and prevention activities, i.e. pre restoration and management activities) and then they are compared with another set of simulation runs using 1991-92 and 1991data (after the commencement of restoration activities). The scenarios so obtained actually represent the health of the lakes ecosystem and stress the needs to value the impact of changing health of the lake on economic system. They further through light on prioritisation of future policy interventions which shall be required if the lake is to be managed sustainably.

5.2 Ecosystem Modelling

Ecology literally means “the study of homes”. Haeckel coined the term in 1869 to mean the study of organisms in their organic and inorganic environment. More recently, Krebs (Krebs, 1978) has defined ecology as “the scientific study of the interactions that determine the distribution and abundance of organisms”.

Ecological systems are definitely not ‘stand alone’ systems. Each component in these systems cannot be treated as an individual component because of the many interlinkages present. None of the components can in fact be dealt with in isolation since the entire network of linkages has to be taken into account whenever the system is being considered. For example, if one has to study the population dynamics of a particular species, then an understanding of how this system interacts with other species, the dynamics of all these species and so on are required.

Physical systems are definitely easier to model since initial conditions can be specified and external influences largely eliminated here. But with ecological systems this is a drawback since these may be influenced greatly by external factors such as climate, which may introduce large variations in the system. Thus replicated designs may be impossible to study in ecological systems (Robertson et al., 1991).

Ecosystem modelling involves the depiction of ecosystem functions by changes over time or space (or both) in measurable quantities, thereby allowing some test of the set of process hypotheses at the ecosystem level. Modelling becomes important because it can construct a symbolic representation of the functioning of ecosystems. It can also predict and simulate conditions that might be existent if present trends to continue or new factors introduced into the system. It helps to identify the stress areas in a system and help to develop management strategies to help deal with them. Generally, modelling is used to make predictions about the responses of ecosystems, or components of ecosystems to specify stresses or disturbances.

The first simulation models for ecosystems were developed in the mid-1940s by Gordon Riley, for marine ecosystem primary and secondary production. These models were developed before the advent of the digital computer and required laborious calculations. Present day ecosystem simulation requires use of a digital computer and simulation is now inseparable from the digital computer. (Gordon &Stephen, 1987).

5.2.1 Major Model Types

Models can be classified in many different ways, and it is frequently true that the classification applies more appropriately to parts of models rather than to the model itself and that some models can be put into more than one class.

5.2.1.1 Statistical Models:

These models are simply used to summarise large amounts of data in a mathematical form. The choice of the mathematical form itself has little or no theoretical justification, and the resulting parameter values, obtained by the statistical procedure, have little biological meaning. A common example is the fitting of polynomial equations to growth data, as in agricultural crops or forest stands.

5.2.1.2 Theoretical / Analytical Models:

These are developed from simple theoretical considerations, frequently with little or no basis in observed sets of data. These models are used to explore abstract ecological concepts, such as the coexistence of two competing species, or the relation between complexity and stability in ecological systems. The models are frequently handled analytically, and mathematical tractability is more important than ecological sense. Such models therefore tend to make highly simplistic ecological assumptions (for example, that there is a linear relationship between the amount of food eaten by a predator and the amount of food available), and this makes many of the conclusions of very doubtful value.

5.2.1.3 Numerical Simulation Models

Numerical simulation models involve the literative solution of a mathematically - specified model. In a relatively few cases, such as the statistical simulation of sampling problems, the iteration is over the set of individuals in a population. In the vast majority of cases, the primary iterative loop is forward through a set of points in time. In these cases, the model specifies the changes that take place over one time step, and the model is solved by repeatedly working out changes in the system, then updating the state of the system. (Robertson et al.,1991).

In more simple terms, models are likely to be either conceptual or numerical. Stochastic models use mathematical representations of ecosystems, which take account of probability, so that a given input may yield a number of possible results. Deterministic models, on the other hand, rest on mathematical descriptions of ecosystems in which relationships are fixed, so that any given input invariably yields the same result (Allaby,1994).

Simulation models consist of a collection of hypotheses, in equation form, for how the major elements of the model (state variables) change over time. These hypotheses are usually categorised into several processes controlling the rates of change of the state variables. The choice of processes to consider depends on the major variables in the model and on the degree of detail desired to represent the changes in these variables. These depend in turn on model objectives and on the ecosystem under study. The process rates are combined into a system of *different equations*. These equations give the rate of change of the state variables as a function of their own condition and of other state variables and environmental conditions. (Gordon & Stephen, 1987).

Thus conceptual models assist in the understanding of complex, multivariable problems. Management models should offer reliable predictions of the outcome of alternative approaches to problems that assist the manager to decide the optimal course of action. It is rare for one model to fulfil both purposes. The ability to make a mathematical model which simulates a natural system or process is a measure of the modeller's understanding of that system.

5.3 Bhoj Wetland Restoration Project Executed through EPCO

The Environmental Planning and Co-ordination Organisation (EPCO) was established by the Housing and Environment Department of Government of Madhya Pradesh in 1981. It prepared an action plan on behalf of the Government of Madhya Pradesh for the conservation and management of both the lakes of Bhopal City. The Government of Madhya Pradesh requested the Government of India for financial assistance to implement this plan. The GOI in turn posed this project for bilateral assistance to Government of Japan. The then Overseas Economic Co-operation Fund (OECF) of Japan now called as the Japan Bank for International Co-operation (JBIC) has provided Rs 209.97 crores as loan funds for the implementation of this project. The total project cost is 247.02 crores in which the State Government Contribution is Rs 37.05 crores. The objectives of the Bhoj Wetland Restoration Project are:

- To conserve and manage the Bhoj Wetland that consists of the Upper & Lower Lakes of Bhopal which are now being subject to severe environmental degradation due to pollution.

- To ensure availability of water from the Upper Lake which is one of the major sources of water supply to the city of Bhopal in an increased quantity and satisfactory quality.

Water quantity available for specific uses declines with the extent of pollution flowing into the water body. When quality deteriorates, the economic value of water also gets reduced. With increasing quality deterioration, water uses may successively shift from drinking water to bathing water, water for livestock, agriculture and industrial uses etc. same has been the case of Upper and Lower Lakes where the water quality levels have reduced to Class ‘C’ and ‘E’ respectively. The ultimate goal of the restoration project is to bring the water quality of Upper Lake to the designated Class ‘A’ and that of Lower Lake to designated Class ‘D’ as per the following primary water quality criteria.

Table 5.1 Primary Water Quality Criteria

Primary Water Quality Criteria					
Criterion	Class A	Class B	Class C	Class D	Class E
Dissolved oxygen (mg/l) minimum	6	5	4	4	
BOD (mg/l) maximum	2	3	3		
Total Coliform count (MPN/100 ml.) maximum	50	500	5,000		
PH	6.5-8.5	6.5-8.5	6-9	6.5-8.5	6.5-8.5
Free ammonia (mg/l) maximum				1.2	
Conductivity (micro mho/cm) maximum					2,250
Sodium absorption ratio maximum					26
Boron (mg/I) maximum					2

BOD : Biochemical oxygen demand; pH : measure of the acidity of alkalinity of water, MPN : Most probable number, Mho : unit of conductivity.

Class A : Drinking water source without conventional treatment. Class B : Water for outdoor bathing, Class C : Drinking water with conventional treatment, Class D : Water for wildlife and fisheries, Class E : Water for recreation and aesthetics, irrigation and industrial cooling

Source: Dying Wisdom, CSE Report 1997

This project involves several pollution control and environmental conservation measures. Altogether there are 15 sub projects under this project. These are mainly:

1. Desilting and Dredging of Lakes – Silt deposition in the lakes over the many years has led to numerous problems such as reduction in the storage capacity of the lake, accumulation of nutrients that promote pollution of lake water and luxurious growth of aquatic weeds, algae and other organisms. Because of this deposition, land formation

has also started. Thus the aim of this project is to remove the huge amounts of silt present in the lake beds.

2. Deepening and Widening of the Bhadbhada Spill Channel – This subproject aims to widen and deepen the spillway from the Upper Lake in order to accommodate a discharge of 566 m3/sec so that in case of flood threats water can be released easily from the spillway, thus reducing stress on the earthen dam at Kamla Park. The deposition of silt in the spillway obstructs the smooth flow of water in the approach channel to the spillway. Further the deposi

Plate. 5.1 Deepening and widening of spill channel r.

3. Restoration of Takia Island – The Takia Island on the Upper Lake has a mazhar of the Shah Ali Shah Rahmatullah Allaih which has a religious significance. The objective of the sub project is to restore the island's shape and form by preventing further erosion and prevent the accumulation of silt around it leading to the proliferation of weeds and subsequent land formation and shifting of the land mass.

4. Afforestation & Creation of Buffer Zones – In order to prevent encroachments, human settlements, movement of cattle and cultivation etc., buffer zones have been created particularly in the Western, Southern and Northern fringe area of the lake. This plantation is also being carried out in the catchment area of the Upper Lake to control and check soil erosion. Under this sub-project, more than 15 lakhs plants are being

Plate5.2. Plantation site under Afforestation Programme

planted in 872 hectares of land. The species planted are mostly biomass producing and medicinal plants. The co-operation of the people is being solicited for this programme.

5. Construction Of Check Dams, Silt traps, Toe Walls and Cascading for Controlling Silt Entry – This catchment area treatment is being carried out to mitigate inflow of silt, agricultural residues and other wastes etc., into the lakes through mechanical obstructions created on the nallahs discharging these into the lakes. 78 structures on the nallahs of the Upper Lake and 5 on those of the Upper Lake are planned.

Plate 5.3. Gabien structure near Lower Lake

6. Construction of Garland Drains - This sub project is an ambitious one that envisages the construction of a garland drain around the Lower Lake for catching all the non point sources of pollution. The Lower Lake receives its inflow from 28 nallahs and drains. It is being tried to control the inflow of sewage and sullage into the Lower Lake by provision of surface drains/pipe drains connected to the sewerage system which shall divert this water away from the lake and to prevent entry of silt into the lake coming through different streams joining the lake.

7. Prevention of Sewage Pollution – The aim of this sub project is to provide an improved sewage system in the areas which drain into the upper and Lower Lakes so that sewage and waste water from these areas can be collected and diverted away for treatment.

8. Retghat – Lalghati Link Road – The objective of the construction of the link road between Retghat in the old city and Lalghati in the northern side of the Upper Lake is to prevent human intervention in the fringe area of the lake by creating a physical barrier

between the human settlement and the lake. The secondary objective of the road construction is to off load the traffic through old city and divert it through this new road.

9. Solid Waste Management – The main aim of this sub project is to improve the solid waste management and facilities within the catchment area of Upper and Lower Lake in order to prevent pollution of the lakes by the direct or indirect entry of solid wastes into the lakes. The municipal Corporation is able to collect only 96 tonnes per day as against the 131 tonnes of garbage produced in the city everyday. This project aims to create an effective system of waste disposal and recycling of lakes.

Plate 5.4 Solid waste collection bins at Gandhi Medical College

10.Prevention of Pollution from Dhobi Ghat – This sub project at the Lower Lake comprises shifting of the Dhobighat and the slums therein from their present location on the Lower Lake and develop the land thus vacated. Large quantities of detergents, chemicals and furnace ashes enter the Lower Lake on a daily basis due to all these washing activities. Attempts are being made to motivate the Dhobi community for voluntary shifting.

11.Deweeding – This sub project looks after the cutting, uprooting, and harvesting of shoreline, emergent, submerged, floating weeds and algal blooms from the shoreline and shallow sections of the lakes. It is hoped to improve the quality of water and prevent the accelerated evapotranspiration of lake water, through this measure. Controlled deweeding operation would be helpful to reduce nutrient level as well as maintain the ecological balance of the lakes.

12. Monitoring of Water Quality – Through regular monitoring by means of setting up a highly sophisticated laboratory, physico-chemical and biological parameters and heavy metals in the lake waters can be assessed. The effect of pollution from different sources and their intensity and quantum can thus be calculated.

13. Installation of Floating Fountains – The objective of installing floating fountains in the Lower Lake is to oxygenate the lake through aeration. The oxygenation is helpful to the biotic component of the lake.

14. Biological Control through Aquaculture – It is also proposed to biologically control aquatic weeds and plants with a view to improve the quality of lake Water using aquaculture. For this programme co-operation of the local fishermen becomes very important and it is hoped that this programme shall have a direct and positive impact on the economy with the increase in supply of fish as a food and upliftment of the living standards of fishermen.

15. Public Participation & Environmental Awareness – The participation of the local people in this Project is essential for its success. To achieve this co-operation, it is necessary to educate and train the public through a planned environmental awareness programme with the help of NGOs and other educational institutes. The objectives of this programme are to associate the residents of Bhopal with the various activities regarding environmental conservation of the lakes of Bhopal; to mobilise different segments of the society to ensure participation in various environmental protection and conservation programmes; manpower development to ensure implementation of development programmes without environmental degradation.

5.4 Ecosystem Model for Bhoj Wetland

Wetland models have been very much in focus during the last five to eight years due to an increasing interest for these ecosystems as habitats for birds and amphibians. Restoration of previous wetlands or erections of new wetlands seem furthermore to be the most effective method of abatement of nutrient pollution from non-point sources

(agricultural pollution). This has obviously increased the demand for good management models in the area.

Bhoj Wetland, the lifeline of Bhopal, being a man made reservoir within the city is facing threats due to various anthropogenic activities inside and outside the lake area. The primary use of the lake, as mentioned, is providing drinking water to nearly half the city's population. The drinking water quality has been deteriorating steadily over the years owing to increased human activities in the region.

A detailed conceptual model with causes, impact and feed back control strategy (restoration and pollution prevention activities) has been developed using Oakerson's Basic Interaction Model for Common property Resources Management (Fig.5.1). It attempts to assess the impact of economic, ecological, social and technological factors on the lake' ecosystem and suggests the control strategies through the feedback mechanism and thus follows a holistic approach for the sustainable management of Bhoj Wetland. But due to lack of availability of data the model presented here has considers only the basic water quality parameters. Though indirectly the pressure of economic, social and technological factors does gets expressed in terms of changing values of these parameters but not so explicitly.

Thus a detailed ecological model linking basic parameters and their impact on water quality has been developed. Though it is clear that the linkages are very complex, to the extent data and information are available, and to the extent the parametric specifications stand the test of stable relationships, the model is put to explain the eco-system dynamics. Therefore, one may not take this model to be a complete description of the ecology of Bhoj Wetland. Here the model variables are selected drinking water quality parameters.

5.4.1 Model variables

The goal of management is to balance the uses of lake with conservation measures to sustain ecosystem services over time. Lake degradation is a syndrome with multiple causes. Because lake degradation has multiple causes, lake restoration usually

requires multiple interventions. The basic ecological parameters brought under the purview of the conceptual model for Bhoj Wetland are weeds and sewage. All are linked with each other in one way or another. The water quality parameters like Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH, Total Hardness, Total Alkalinity, phosphate, Turbidity, Total Dissolved Solids (TDS) and Bacterial Count are linked with these variables and with each other (all these parameters and their permissible range are described in Glossary) and their dynamics in the lake's ecosystem is explained below.

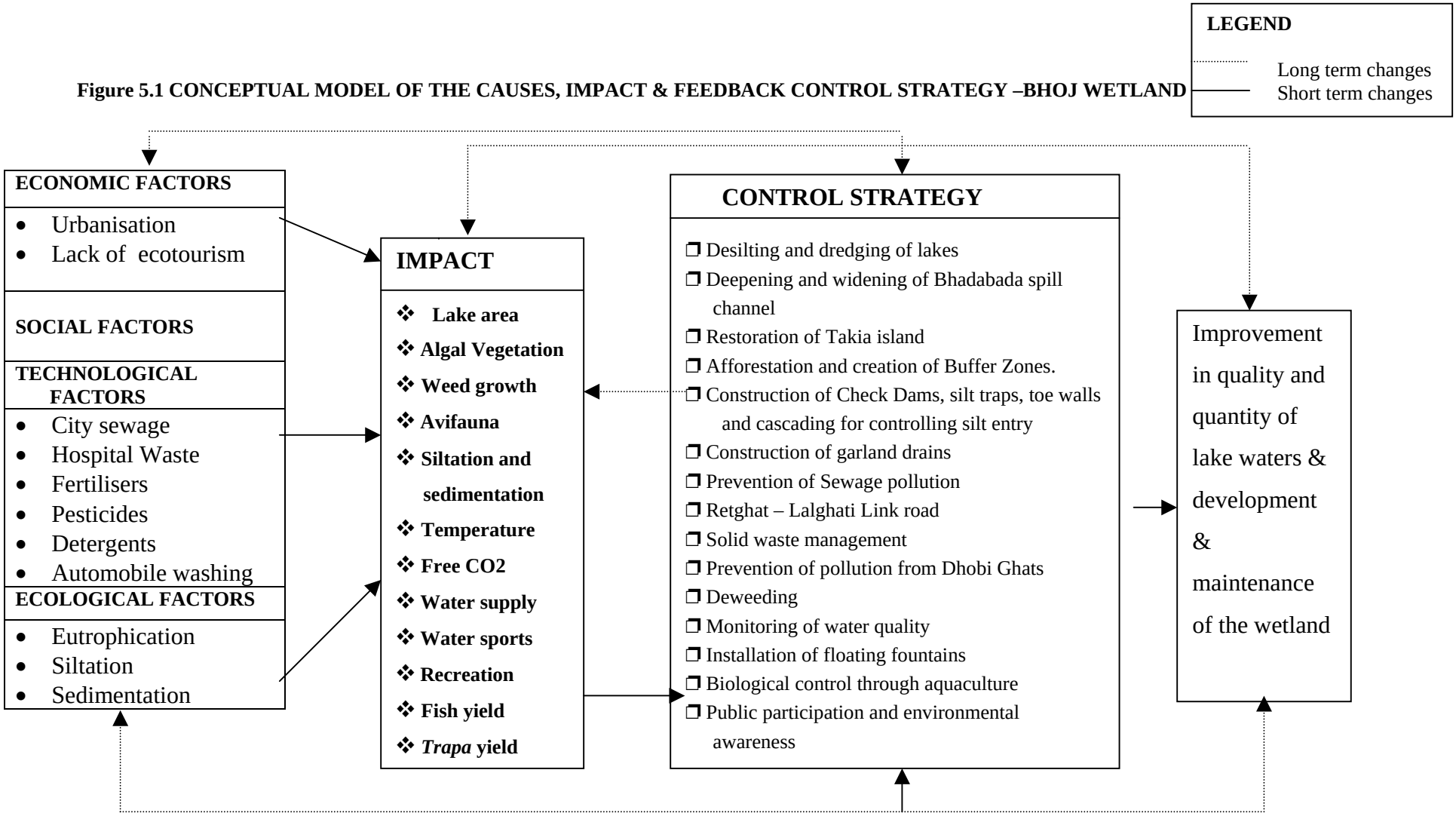
5.4.1.1 Bio Chemical Oxygen Demand (BOD),

BOD, an important water quality parameter, shows the level of biodegradable waste pollution. The BOD value of the system is affected by sewage which releases nutrients and biodegradable domestic waste (food wastes) in the lake waters. BOD is also affected by total solids which itself is dependent upon household wastes coming through the sewage. BOD shows a positive link with bacterial count and total dissolved solids. Dissolved Oxygen (DO) content of the water body affects the BOD greatly. A high DO value indicates good primary production and life supporting potential of the system.

5.4.1.2 Bacterial Count

Bacterial Count can provide a better picture of drinking water quality. Total bacterial count through Maximum Probable Number (MPN) technique shows the number of bacterial pathogen(*E.Coli*) present in the sample of water. They are the causative agents of many water borne human diseases. The bacterial count has increased in an alarming way in the Bhoj Wetland over the last few years. In this model the bacterial count is connected to sewage, pH, turbidity and BOD. The change in pH value affects bacteria the most. Similarly, high BOD means more biodegradable material in water which also provide nutrients to bacteria. Total solids are also linked with the increase of bacterial count. But the main source of the bacteria is the waste (solid and sewage) from the hospitals and houses.

Figure 5.1 CONCEPTUAL MODEL OF THE CAUSES, IMPACT & FEEDBACK CONTROL STRATEGY –BHOJ WETLAND



Developed for Bhoj wetland using Oakerson's Basic Interaction Model for Common Property Resources Management

5.4.1.3 Total Hardness

Total Hardness is the sum of hardness due to calcium and magnesium ions present in the water. This is linked with the geological conditions of the catchment area. Soil structure and land use practices of catchment area affects its value. In this system it is linked with sewage and total dissolved solids. The high hardness makes white precipitates in the boilers and consumes more soaps and detergents while washing in such waters.

5.4.1.4 Dissolved Oxygen

Dissolved Oxygen is an important parameter of all ecosystems because it controls life inside the water. Very low oxygen indicates high polluting levels of oxygen demanding wastes and lack of primary production. Temperature, turbidity, phytoplankton count and high BOD are the controlling factors of Dissolved Oxygen.

5.4.1.5 Total Phosphate

Total Phosphate content in the lake water indicates the pollution from sewage and agricultural run off. This is the limiting nutrients for primary production and helps excessive growth of weeds and lower aquatic plants. Fertilisers and detergents are the main sources of inorganic phosphate which plants can absorb directly. Organic phosphates of living cells and dead cells also contribute phosphate to the system. High value of phosphate is considered nutrient rich condition of the water body, leading to eutrophication.

5.4.1.6 Turbidity

Turbidity of the lake is related the suspended and colloidal particles of the water. It reflects or hinder the light penetration, thus impact on primary production and dissolved oxygen value of water body. Turbidity can measured in Naphalo Turbidity Units (NTU) and here mentioned Formazin Attenuation Unit (FAU) which is equal to NTU.

5.4.1.7 Inter-linkages of Various Parameters

The inter linkages in the model may be illustrated by one parameter, say sewage coming to the lake. Sewage from the city household waste contains mainly water, food wastes and detergents with silt. It increases silt content of the lake water and reduce the lake area. It leads to eutrophication by bringing more nutrients that cause excess weed growth. This causes lake area reduction and affects the BOD of the ambient water of the lake.

Weed growth has its ecological benefits and is a cause of problems to the system too. It helps in biodiversity conservation by providing a nesting and breeding ground to fish and provides food for a number aquatic and avian fauna. It is also responsible for the bio treatment of sewage, i.e., nutrient retention, as filter to the silt and as primary producer giving dissolved oxygen to the water. But excessive growth of weeds reduces the water spread area, increases evapotranspiration (increases water loss), creates problems in fishing and navigation. The decayed parts of the weeds add more nutrients to the sediments and increase BOD in the lake waters. It also produces bad odour and breeding grounds for mosquitoes and other vectors. The drinking water quality gets affected by this, and a high cost for treatment of such water has to be incurred. Weed growth is affected mainly by sewage because it provides more nutrients which encourages such growth. It itself then affects bacteria, BOD and Turbidity. Thus weeds can adversely affect lake area and BOD but has positive link with dissolved oxygen of the lake.

5.4.2 Linkages of Model Variables with Population

All these parameters are directly linked with the population change. Increase in the population over the years has obviously led to an increase in the amount of sewage inflow into the water body. Population increase has also led to increase in development activities and encroachment in the catchment area resulting in more siltation and solid waste entry into the lake.

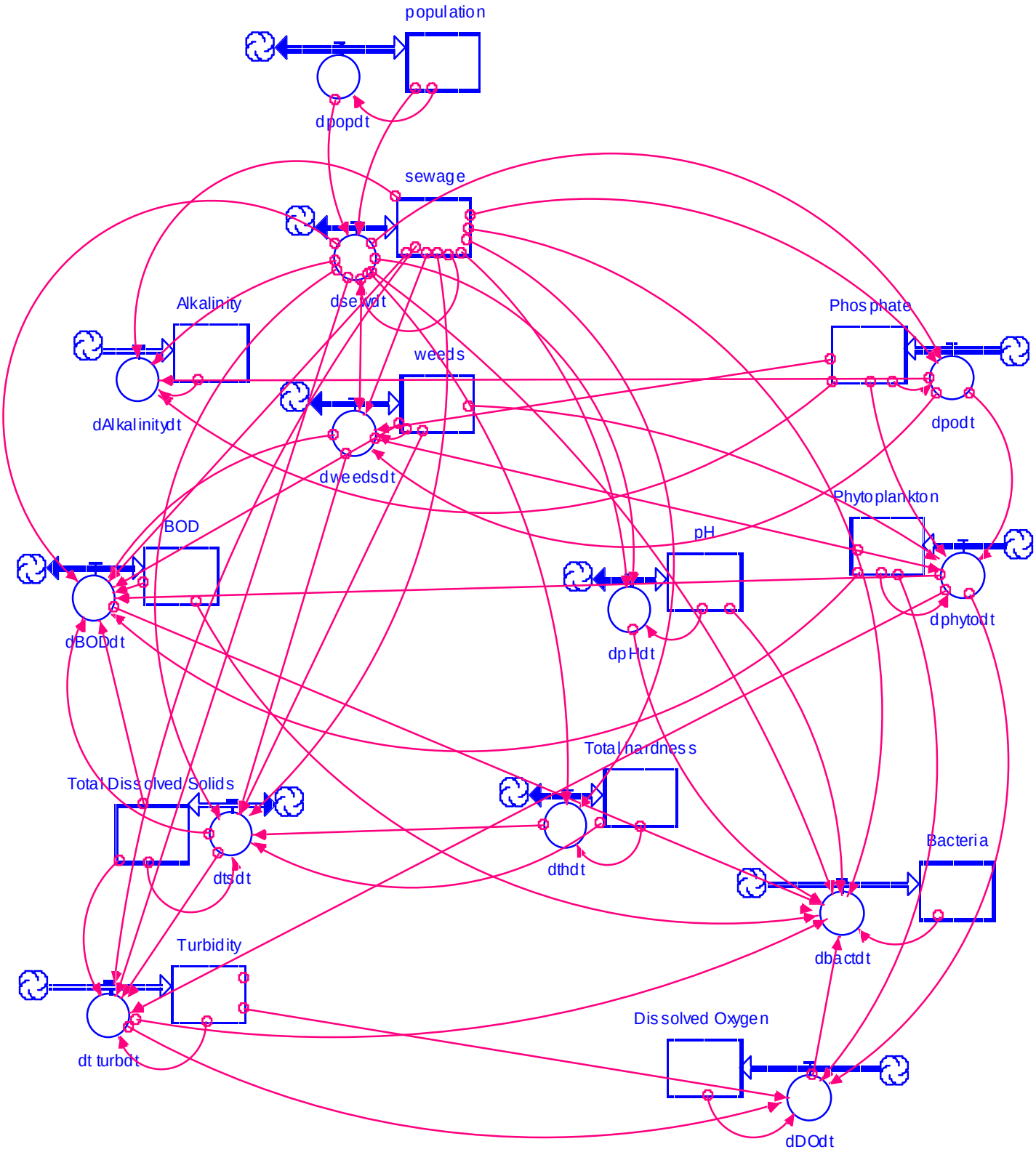
Population growth in the adjacent areas of the lake is the most important factor of pollution. Encroachment in this area is considered in the restoration activities and useful measures like physical barriers (Link road) have been taken to check further encroachment. Increase in population increases water consumption and generate more waste water. Increase in sewage quantity affects the system adversely. In this model population of the wards nearing the fringe area of lake are taken for each lakes separately.

The Ecosystem Model for BWL using above parameters is depicted in Figure 5.2

5.4.3 Assessment of Impact of Ongoing Restoration Activities

The present scenario of the lake, undergoing restoration activities, is quite different from the situation of a few years back. The major changes have been in the quantity and quality of the sewage and weed infested area of the lake. After desiltation and dredging the lake area and volume will also change. The total impact of the restoration activities are yet to be quantified. The restoration of Bhoj Wetland which include Upper Lake and Lower Lake gives priority to its drinking water use in Upper Lake. The water quality in the Lower Lake is not in this criteria so can be used for other purposes like fresh water aquaculture and tourism activities.

Figure 5.2 Ecosystem Model for Bhoj Wetland Using Water Quality Parameters



To find out the impact of ongoing restoration activities, the basic model has been simulated in two ways and the data of pre restoration stage and ongoing project activities is used separately. The two models show the variance in their stimulation out puts. Using the available data first model has been developed for the pre restoration state for Upper Lake. In this model base year data of year1985 is compared with the water quality data of year 1992.The post project implementation model has been made separately for each lake. The basic structure of the model for both the lakes is same with some variation in the variables. The 1993 base year value of water quality data has taken here in the case of Upper Lake and data of year 1991 is used for Lower Lake and both are compared with 1999 data population data of the wards adjacent to each lake is used taking 1991 census data and compared to the estimated population of year 2001. The ecology of lake may change after the completion of restoration projects which are targeted to be completed by the year 2001.

The year 1999 data of ambient water for both lakes is calculated from the station wise data collected from the monitoring sub project of Bhoj Wetland project. The seasonal surface samples data of five sampling stations of Upper Lake and two sampling stations of Lower Lake for four seasons is considered for calculating the average value of water quality of year1999. As the Upper Lake is a large water body having different catchment area land use shows variation in the water quality in various stations. So it is necessary to take the maximum diversified and distant stations to cover the total area of the lake. The stations selected can give maximum variation of the water quality.

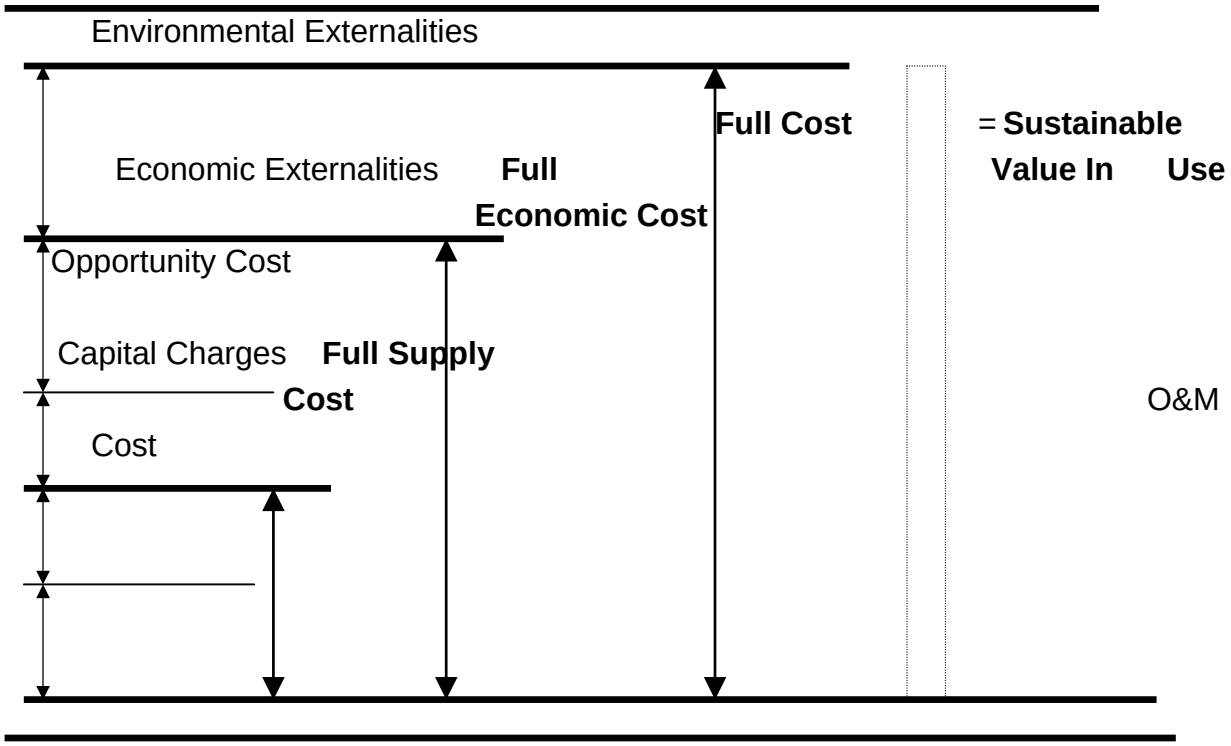
Lower Lake is small water body compared to the Upper Lake. Even though the limnological conditions in the sampling stations selected are different. Two sampling stations of distant locality and where maximum management activities have been done are selected to calculate the average value for 1999.

CHAPTER VI : USE VALUES OF BHOJ WETLAND: PRODUCTION FUNCTION, CVM AND HEDONIC PRICING APPROACH

The Economic Valuation of the Bhoj Wetland encompasses all values that have been currently extracted and have been calculated as part of this study. The values are supposed to capture intrinsic values as well as the extrinsic ones. The various values that have been calculated as per their methodology specified in the previous chapter, are dealt herewith in details in this chapter. It is restated that the attempt has been only to capture various actual / current use values through direct and indirect valuation techniques and not to capture options and existence values. All actual use values so calculated are not totalled to arrive at annual Total Economic Value (TEV) estimate as there could be possibility of overlapping of such values specially in the case of the stakeholder extracting multiple values from the wetland. Instead various use values as well as the impacts are estimated stakeholder wise to reflect the economic importance of the Bhoj Wetland.

There are several general principles involved in assessing the economic value of water and the costs associated with its provision. First, an understanding of the costs involved with the provision of water, both direct and indirect, is key. Second, from the use of water, one can derive a value, which can be affected by the reliability of supply, and by the quality of water. These costs and values may be determined either individually, or by analysis of the whole system. Regardless, of the method of estimation, the ideal for the sustainable use of water requires that the values and the costs should balance each other; full cost must equal the sustainable value in use.

Fig 6. 1: General Principles for Cost of Water



Source: Peter Rogers et al. (1997)

6.1 Valuing Direct Uses

Under this method it has been tried to value all the direct economic benefits of the lake generated either by direct costing or market pricing or existing productivity stemming out of the wetland. The various uses values and the techniques of valuation followed are as under:

6.1.1. Valuation of drinking water supply

Full Supply Cost includes the costs associated with the supply of water to a consumer and is composed of two separate items: Operation and Maintenance (O&M) Cost, and Capital Charges, both of which should be evaluated at the full economic cost of inputs. Since in this particular exercise only the cost of distribution of water in one particular year is actually taken into consideration, the capital charges can be safely ignored.

There are altogether four agencies that obtain water from the Upper Lake for drinking water. These are the Public Health and Engineering Department that provides water to the people in the city, the Bharat Heavy Electricals Ltd. a large public sector concern, the Military Engineering Services stationed at Bairagarh and Sultania Infantry Lines and the Indian Railways. The latter three agencies pay annual charges to the Bhopal Municipal Corporation for use of water from the Bhoj Wetland.

The annual rental and other recurring expenses of these agencies over water supply for the year 1999-2000 are as follows:

I. Public Health & Engineering Department

Quantity of water drawn from the Lake	14.5 MGD
Expenditure	
i) Operation & Maintenance Costs	Rs 27,00,000/-
ii) Electricity charges	Rs 3,31,00,000/-
iii) Chemicals	Rs 20,00,000/-
Total Expenditure	Rs 5,89,00,000/-

(Source: PHED Office)

II. Central Railways

Quantity of water drawn from the Lake	1.24 MGD
Expenditure	
i) Chemicals	Rs 7,07,940
ii) Water rate paid to BMC	Rs 11,14,008
iii) Electricity charge	Rs 25,31,064
iv) Operation & Maintenance Costs	Rs 3,48,240
Total Expenditure	Rs 43,53,012

(Source: AEN Office, Bhopal Division)

III. Bharat Heavy Electricals Ltd.

Quantity of water being used by BHEL	6.5 MGD
Expenditure*	
i) Chemicals for purification	Rs 5,49,950
ii) Water rate paid to BMC	Rs 1,00,00,000
iii) Electricity charges	Rs 1,00,00,000
iv) Operation & Maintenance Costs	Rs 16,75,000
Total Expenditure	Rs 2,22,24,950

* Approximate figures

(Source: BHEL)

IV. Military Cantonment Area

Quantity of water being used by the Cantonment	1.5 MGD
i) Chemicals for purification	Rs 20,00,000
ii) Water rate paid to BMC	Rs 48,00,000
iii) Electricity charges	Rs 24,00,000
iv) Operation & Maintenance Costs	Rs 7,36,000
Total Expenditure	Rs 99,36,000

(Source: CWE, MES, Bhopal)

Thus taking all these various agencies into account the total expenditure on drinking water taken from the Upper Lake comes out to be Rs 9,54,13,962/- or US$ 2,120,310.

On the other hand the entire revenue that is collected from the city of Bhopal as water tax charges are Rs 2,14,64,600/- or US$ 477,000 per annum. This tax includes the amounts paid by all the commercial organisations and people of the city who might be obtaining water from other sources. Thus, a large subsidy is being provided to the people as far as drinking water is concerned. Now, as per the welfare measures that every government fulfils as part of its administrative responsibilities, this is important to a major extent. But when such a large gap exists between the actual expenditure and the revenue generated, it makes sense to re-examine the priorities. The argument over subsidies is never ending but when a subsidy leads to misuse, overuse and then misuse of a system, it does become necessary to provide checks by the way of raising tariffs if required. But the raising of tariffs should again be in lieu of the use systems prevalent in the society. The tariffs for commercial organisations and establishments and higher income groups can be raised substantially while that for the lower income groups could be taxed at a comparatively lower rate. Introducing compulsory meter connections might also raise the revenue being generated and also control use since people would regulate the same if they were in fact paying for every drop that they use as in the case of electricity.

6.1.2 Revenue generated by the MP Tourism Development Corporation (MPTDC) from recreational activities in the Upper and Lower lakes

A. Boating

As per the figures obtained for April 1999 to March 2000, 64,471 tourists came to the lake and opted to boat using the boats of the MPTDC. A large number of tourists take private boats and many more do not go boating but just enjoy themselves by the lakeside. The figures for the various months are shown in Table No 6.1:

Table 6.1: Tourist Inflow to the Upper Lake and Revenue Generated by the MPTDC for the year April 1999 to May 2000.

Month	Number of Tourists	Revenue generated in Rs
April, 1999	NA	1,10,545*
May, 1999	18,565*	1,98,480*
September, 1999	2640	19,800
October, 1999	4224	31,680
January, 2000	5004	37,530
April, 2000	5528	41,460
May, 2000	8596#	64,470#

* Figures and revenue high because motor boats were running at that time.
# Figures high because of peak season again.
Source: Boat club, MPTDC

The total revenue collected for the year April 1999 – March 2000, is thus Rs 6,74,635/-.

In comparison the expenditures are as follow:

i) Salaries	Rs 3,84,000/-
ii) Maintenance	Rs 10,000/-
iii) Electricity charges	Rs 6,000/-
Total Expenditure	Rs 4,00,000/-

Thus the total profits are reduced to Rs. 3,10,635/- for the last year. The MPTDC owns 15 paddle boats which run in the upper lake.

On the other hand the Revenue collected from the Lower Lake is very nominal in comparison. This is mainly because the lake is so dirty that people choose not to visit there. Another major problem that is responsible for visitors not showing up is lack of parking space at the park where boating activities are carried out. There are 4 paddle boats and one motor boat operating under MPTDC there. The boating activities in this Lake have begun only a few months back around April, 2000. The average revenue being earned by them is around Rs 800/- in a week or approximately Rs 3,500/- in a month. And this was only in the peak season. The collections can be expected to be much lower during the off season. This revenue does not even meet the expenses of the boat club but since it is being operated by the MPTDC, the losses are cheerfully borne without much being done to improve things.

B. Cafetaria

The MPTDC also operates a cafeteria called the ***Winds & Waves*** on the Upper Lake that has significant locational and aesthetic advantages. It also has an extension counter right on the lake front near the boatclub. The annual expenditure and the income for this enterprise of the MPTDC is as follows:

i) Annual income	Rs 18,00,000/-
ii) Salary	Rs 4,20,000/-
iii) Operational, Maintenance and Electricity Costs	Rs 14,40,000/-
iv) Bar License	Rs 2,00,000/-
Total Loss	Rs 2,60,000/-

(Source: Manager, Winds & Waves, MPTDC)

In spite of enjoying several benefits besides the locational and aesthetic advantages as mentioned before like the presence of proper parking space, seating arrangements, sunset view points, the establishment still runs in loss is a surprising fact and one that needs to be taken with a pinch of salt. The place definitely has potential and with the competition that it is facing from a new hotel that has come up - Hotel Ranjit Lake View, it is in need of a thorough face-lift.

Thus the total revenue generated by the MPTDC from the Bhoj Wetland taking into account the losses and non-performance of other sites, stands at Rs 76,695/-, a very dismal sum indeed. A very high income generating source for the MPTDC especially since it is the major attraction in the city is being simply wasted since proper utilisation of its potential is not taking place. The MPTDC needs to either privatise its cafeteria and introduce other attractions (see recommendations) in order to attract more customers and thus get more profits.

6.1.3 Income Generation for Private Individuals

A number of people are existent upon the Bhoj Wetland for their daily livelihood. The economic activities and cash transactions of these people have mainly been gathered through talks with them. These can be listed as below:

A. *Fishermen*

There are some 450 odd fishermen families who earn their living through fishing in the Upper Lake waters. These people usually employ gill nets to catch their fish and the major fish species that are available are the major Indian carps like *Catla catla*, *Labeo rohita*, *Clarius sp, Cirrhimus mrigala, Ctenopharyngodon idella and Hypophthalmichthys molitrix and so on*. The catch though is extremely uncertain and on the average a fisherman may get at least Rs 1500/- per month as his earnings from this activity.

Thus the annual total earnings of the entire fishermen community can be generalised as Rs 81,00,000/-. The fishermen also pay an amount of Rs 1,00,000/- as annual lease amount to the Bhopal Municipal Corporation. Thus the total earnings to the fishermen can be put down as Rs 80,00,000/-.

B. Boatmen

There are a number of private boatmen who ply their boats in the Upper and the Lower Lakes. Altogether there are 20 paddle and rowboats in the Upper Lake and 7 in the Lower Lake. The average earnings from boating are as follow:

During season for Upper Lake	
Average income per boat during the week days	Rs 500/-
Average income per boat on Sunday	Rs 1500/-
Assuming the season to last from March to June,	
average income during the season for all the 20 boats	Rs 14,40,000/-
Off season for the Upper Lake	
Average income per boat on a week day	Rs 150/-
Average income per boat on Sunday	Rs 500/-
Assuming the off season to last from July to February,	
Average income during the season for all the 20 boats	Rs 8,96,000/-
During season for Lower Lake	
Average income for all 7 boats on a week day	Rs 500/-
Average income for all 7 boats on Sunday	Rs 1500/-
Assuming the season to last from March to June,	
average income during season	Rs 72,000/-
During Off season for the Lower Lake	
Average income for all boats on a week day	Rs 200/-
Average income for all boats on Sunday	Rs 600/-
Assuming off season to last from July to February,	
Average income for all the boats	Rs 57,600/-

After paying of the boating license fee, we can assume that annual profits of Rs 1,01,880/- are being earned through boating activities in the Lower Lake.

Therefore adding the figures for the Upper Lake as well as the Lower Lake, boating yields an annual income of Rs 24,37,880/- for private boatmen.

C. Trapa Cultivation

There are some 500 families involved in Trapa cultivation and according to the cultivators each family gets around Rs 10,000/- on average per annum which comes as a lump sum on the sale of the harvest usually in the month of September – October.

Therefore the total income generated through the cultivation and sale of *trapa* amounts to Rs 50,00,000/-.

D. Washing of Clothes

According to a survey, there are estimated to be 314 D*hobi* families settled along the banks of the Lower Lake. Out of these 113 families are engaged in the profession (SAPROF, 1994). As per the talks with various representatives of the *Dhobi* community, it has been found that there are some 100 families at present, which carry out washing of clothes in the Lower Lake. On an average these people earn some Rs 3000/- a month. At this rate, the annual income generated from all washing activities in the Lower Lake amounts to Rs 36,00,000/-.

E. Road side vendors

The average annual income of the various kinds of vendors is as follow:

a) Maize cob sellers

There are usually 10 vendors on weekdays and 20 on Sundays. The average income on a weekday is around Rs 100/- per vendor and on Sunday it rises to around Rs300/-. Taking these figures the total transactions on selling of maize cob for three months in a year amounts to Rs 1,44,000/-.

b) Sugarcane juice

There are usually 8 vendors on weekdays and 15 on Sundays. The average income on a weekday is around Rs 200/- per vendor and it rises Rs 500/- on Sunday. Assuming these figures and that the sale of sugarcane juice occurs for four months in summer, the total income generation amounts to Rs 2,73,600/-.

c) Snacks and cold drink stalls

There is usually 1 vendor during the off season time and 3 during the season on normal weekdays and 3 during off-season on Sundays and 5 during the season. The average

income of these people is around Rs 100/- per weekday during the off season and Rs 250/- on Sundays and Rs 400/- per day during the season, and Rs 600/- on Sundays. Since they are more or less permanent their annual income amounts to Rs 2,06,400/-.

d) Horse rides

There are altogether 10 horsemen who give horse and pony rides on the lake front. Their incomes during the season range from Rs 300/- on a weekday to Rs 1000/- on Sunday per horse and during the off season Rs 125/- on an average per weekday and Rs 325/- on Sundays again on an average. With these figures, the horsemen earn an amount of Rs 7,92,000/- per annum.

Thus the total income generation by private individuals through their economic activities in the Upper and the Lower Lake amount to a total of Rs 2,04,53,880/-.

6.2 Cost of Illness Approach and Defensive Costs

With the increasingly deteriorating water quality, and the outbreak of various water borne diseases in the city every year, the people are resorting to various defensive measures such as use of purification devices such as Aquaguard and Zero B. On the other hand if a person does fall ill on account of such a water borne disease, the expense borne by him or her turns out to be a major cost. The number of days lost as productive work days also adds to this cost of illness.

The number of cases of water borne diseases has been obtained from the Directorate of Health Services, from the year 1995 to 1999. It can be observed from Table No. 6.2 that the cases of all the water borne diseases show a marked decline in recent times. The reasons for this can be that this data is obtained only from government hospitals and people all over are showing a trend of moving towards private practitioners in spite of the fact that they might have to pay more, in order to get better services.

Table 6.2: Reported Cases of Water Borne Diseases in the Bhopal City

YEAR	GASTRO ENTERITIS	DIARRHOEA	CHOLERA	JAUNDICE	TOTAL
1995	N.A*.	N.A.	N.A.	770	7391
1996	1068	9280	9	136	10493
1997	921	9461	5	168	10555
1998	986	7740	4	58	8788
1999	193	7170	3	58	7424

* Not Available
Source: Directorate of Health Services

It can be assumed based on a survey of local doctors that the estimated expenditure on each of these diseases for a common person turns out to be something like:

1. Gastro-enteritis - Rs 250/- for a period of five days on average for a case of mild intensity.

2. Rs 1500/- on average if the patient needs to be hospitalised.

3. Diarrhoea – Rs 250/- again and Rs 1500/- for hospitalisation

4. Cholera – Rs 3000/- for 3 to 4 days since it requires hospitalisation

5. Jaundice – For mild cases it requires medication for nearly 30 days. Causes expenditure of nearly Rs 3000/-. If hospitalised for 6 – 8 days, the total expenditure may go up to at least Rs 8000/-.

These figures only give a partial view since most people do not visit government hospitals but private practitioners. Even the if we take the figures that have been obtained and examine the cases reported only in 1999, it can be concluded that the amount that people have spent only on medical care would amount to Rs 20,23,750/- (Verma, Bakshi & Nair, 2000). Most of these patients would off course be kids but along with them one of the parents would have to take time off from work. Assuming daily wage rates of Bhopal city for one adult for each of the patients and multiplying with the days off from work as 2 for gastro-enteritis and diarrhoea and 5 for cholera and 10 for jaundice, the cost of man days lost in 1999 would amount to Rs 6,89,310/-. Now this figure is only for the cases that are reported in government hospitals. The actual amount

would be much higher but this at least provides a starting figure. Thus the total losses on account of water borne illness would amount to Rs 26,67,232/-.

This figure pertains to the entire city of Bhopal but if we make an approximate estimate for such cases reported from 45% people dependent on water supply from upper lake, the cost needs to be reduced to 45% of the total (though it is highly underestimated figure) it would come to Rs. 12,00,254/- only as cost of treatment for water borne diseases for people using lakes water.

As a result of the high risk of such diseases and the large number of cases of water borne diseases every year (reported cases are definitely lesser than the actual number of cases), many people use preventive measures such as home water filtration devices, Hepatitis B vaccinations and so on. The total number of water purifiers purchased in the last few years and the costs incurred in their installation are as given in Table No. 6.3:

Table 6.3: Costs incurred in household water purification techniques

Year	1995 – 96	1996 - 97	1997-98	1998 - 99	1999 – 2000
Units of 'Aquaguard'	807	1495	1511	2050	2592
Units of Zero B	10000	13000	12000	20000	30000
Total Cost in Rs	4591830	8506550	9201990	12484500	15785280
	2800000	4355000	4740000	7900000	11850000
Adjusted costs	6428562	18714410	11042388	13732950	15785280
	4099480	5796505	5735400	8690000	11850000
Total costs	10528042	24510915	16777788	22422950	27635280

Source: Eureka Forbes Ltd., Bhopal Office and Ion Exchange Office, Bhopal

The total purification costs incurred by the people from the year 1995 (April) to 2000 (April), therefore amount to a total of Rs 10,18,74,975 (US$ 2,263,888). Taking the total number of households in Bhopal as 2,87,183, the cost of water purification per household comes out to be Rs 355 (US$ 8) in the last five years.

Now, both the water borne diseases as well as the water purification measures costs cannot be attributed to only the water coming from the Bhoj Wetland. Many of these households may be getting water from other sources and not from the Bhoj Wetland. Unfortunately, separate data is not available for this. This cost incurred by the people

actually reflects the social cost or what people would actually be willing to spend on clean and pure drinking water. If the Bhoj Wetland or the other sources of water provided water that was pure and fully safe for drinking this cost could have been avoided. But since the people are dissatisfied with the water quality they spend so much on improving the kind of water they get or on their health. Like the previous case if we again take the 45% of the total purification cost incurred by the individuals to reflect for the population dependent upon water supply from the upper lake, it would come to Rs. 1,24,35876/- which is the economic value of the Bhoj Wetland as a reflection of what people would be willing to pay in order to obtain pure drinking water.

6.3 Contingent Valuation Method

The CVM has been discussed in great detail in the Status paper preceding this report and the sampling design and all have been discussed in the methodology section. In this section, the questionnaire and analysis of the CVM results obtained has been presented.

6.3.1. The Questionnaire

The project team developed the questionnaire after exhaustive literature review. It was then sent to various experts at different Universities in the United States and United Kingdom, to obtain their comments, criticisms and review. Changes were made accordingly in the questionnaire and then an Experts' Meeting was called at Delhi where persons who had previously worked in the field of contingent valuation were called and their comments on the questionnaire contents were invited. Finally, the draft questionnaire was finalised and a pre test for the same was carried out. On the basis of the results of the pre test the draft was modified to obtain the final version of the questionnaire. The format of the questionnaire was as follows:

Attitudinal Questions: The first section aimed at making the interviewee comfortable by asking some questions regarding their view and opinion on various problems plaguing the country. Then these questions were followed by a few, which were aimed at obtaining information regarding the water supply to their homes. Next came questions

aimed at finding out whether the people were aware of the various problems that pose a threat to the Lake.

Scenario Building: In the second section information was given to the people about the proposed Bhoj Wetland Management Society, and their action plans and created the scenario before the people, by telling them about the benefits that they would be getting from the activities of this Society. They were told about the increased recreational benefits and aesthetic beauty and this was to be the basis of their valuation of these benefits. They were shown photographs of the lakes from different angles showing the dirt in the lakes and the view from a distance where the Lakes seemed very beautiful and clean. Besides, they were shown charts showing the structure of the Society and its role (attached in Annexures V a &V b).

Valuation: After the pre-test, two types of payment vehicles were considered. One of these was a voluntary payment to the body which would take up the management of the Bhoj Wetland in the future and which has been called the Bhoj Wetland Maintenance Society and the people making voluntary contributions would get privilege membership of the society to enjoy various benefits from Bhoj wetland on nominal tickets. The second payment vehicle was a compulsory tax imposed upon the people of the city and the collections of which would go to this maintenance Society and people will not get any privilege membership to the society. An open-ended bidding game was used and the respondents were asked a follow-up question to their initial non-zero bid, which was a close-ended question. This was followed by a question that mentioned the finite income that they had and if they wanted to change the initial figure given by them. The above question sequence was based on a study carried out by the Institute of Economic Growth, on “Measuring Non-User Benefits from Cleaning Ganges. The logic that the authors (James and Murthy, 1997) provide that although there is a debate currently in the literature about the use of open-ended bidding or close-ended bidding process, there seems to be insufficient cause for rejecting the former in favour of the latter. This questionnaire format tried to avoid the range biases by adding two follow up questions to the initial open-ended question, the first of which was a close-ended question based on the answer to the initial open-ended question asked.

Table 6.4: Bidding Format of the CVM Questionnaire

Initial Question (Open-ended with a variant of the payment card)	**Initial** (Non-Zero) **Response Range**	**Follow-up Questions** **Question 1** (Close-ended but based on the initial response)	**Question 2** (Open-ended)
"How much money would you and your family pay voluntarily, every year, to enjoy the improved recreational and aesthetic benefits of the Bhoj Wetland?"	Rs 0 – Rs 250 Rs 251 – Rs 500 Rs 501 – Rs 1000 Rs 1001 – Rs 2000 More than Rs 2000	Since you are probably doing such a valuation exercise for the first time, ……" would you pay Rs 300 750 1500 3000 5000 per year on behalf of yourself and your family, in order to enjoy an improved Bhoj Wetland?	"You have a limited income and in that case do you think that it will be possible for you to pay the amount that you have stated. If you want you can still adjust the amount"

Source: Adapted from James and Murthy, 1997

In the questionnaire a table detailing the amount to be asked in the first follow-up question, based on the amount offered as the initial bid, was included as was done in the James and Murthy study mentioned above. This was followed by a question that gave the people a chance to adjust the figures quoted by them considering that their income was finite and not unlimited. The bidding format used was as given in Table No. 6.4 above.

The fourth section dealt with the socio- economic details of the persons interviewed. These variables were used in the regression estimation of the valuation function. Information was collected on education level, occupation, number of adult members and children in the house and gross annual income from all sources.

The next section was the respondent's evaluation whereby a few questions were asked to them regarding the evaluation of the respondent's way of asking the questions and the clarity and their conviction in the valuation technique. Questionnaires that reflected low level of answering were screened out.

The last section was the enumerator's evaluation and declaration. In this section, the enumerator was supposed to answer two questions dealing with their opinion about the respondent's understanding and attitude while answering the questions. Questionnaires where the enumerators mentioned lack of understanding or a non-serious attitude were eliminated from the analysis. The declaration was included to instil responsibility in the enumerators about carrying out the survey honestly and elicit accurate responses from the respondents.

6.3.2 Estimation results

The total number of filled questionnaires obtained at the end of the survey numbered 1497. Then the questionnaires were screened to eliminate incompletely filled ones and also the respondents evaluation of the enumerators was not good or where they showed a lack of conviction in improvements that were mentioned as part of the scenario and also where the enumerators mentioned lack of understanding or seriousness on part of the respondents. Ultimately, the number of questionnaires was reduced to 804. Nearly 46 per cent of the samples were dropped during the screening process. This was done mainly to maintain the accuracy of the sample.

Econometric Model

Two regression equations were estimated for the model one for each of the two payment vehicles used in the survey. In the first equation the dependent variable is thus the Willingness-to-pay voluntarily FINVOL, for improved recreational and aesthetic benefits from the Bhoj Wetland. In the second equation, the dependent variable is the Willingness-to-pay in the form of a tax, FINTAX, for the same benefits. Both of these are then regressed on a vector of socio-economic variables such as income and education level, as well as a number of dummy variables.

General form of the equations:

1. FINVOL = *f* (CONSTANT, INCOME, EDULEVEL, DISTANCE, MINMEM, ADMEM, LNTRES, FREQVISIT, POLL)

   where, FINVOL = the voluntary WTP

   INCOME = the annual income of the entire family

   EDULEVEL = the education level of the person interviewed

   DISTANCE = the distance at which the house of the person interviewed is situated from the lakes.

   MINMEM = number of minor members in the family

   ADMEM = number of adult members in the family

   LNTRES = Length of residence

   FREQVISIT = frequency of visit to the lakes

   POLL = ranking of pollution as a threat to the country

2. TAXWTP = *f* (CONSTANT, INCOME, EDULEVEL, DISTANCE, MINMEM, ADMEM, LNTRES, FREQVISIT, POLL,)

The logarithm linear form of the equation

$LOGFINVOL = \alpha + \alpha_1$ LOGINCOME + β_1DISTANCE + β_2LNTRES + β_3EDULEVEL + β_4MINMEM + β_5ADMEM + β_6FREQVISIT + β_7POLL

The estimated results of these equations are as follows:

Table 6.5 Value of variables in the Equations

Dependent Variable = LOGFINVOL	Number of Observations = 803	
R Squared = 0.116	Adjusted R squared = 0.106	
F = 11.357	Statistical package used = SPSS 10.0	
Variable	**Coefficient**	**t-statistic**
CONSTANT	0.116	0.403
LOGINCOME	0.483	9.104
DISTANCE	-.01392	-1.003
LNTRES	-0.009542	0.447
EDULEVEL	-0.009542	-0.705
MINMEM	0.04461	1.497
ADMEM	-0.02197	-0.774
FREQVISIT	-0.02197	-0.1658
POLL	0.00825	0.376

Dependent Variable = LOGFINTAX	Number of Observations = 803	
R Squared = .112	Adjusted R squared = .085	
F = 4.213	Statistical package used = SPSS 10.0	
Variable	**Coefficient**	**t-statistic**
CONSTANT	-0.01357	-0.031
LOGINCOME	0.454	5.285
DISTANCE	-.01049	-0.188
LNTRES	-0.03942	-0.483
EDULEVEL	-0.08224	-1.199
MINMEM	0.08108	0.966
ADMEM	0.162	2.904
FREQVISIT	0.09281	1.706
POLL	0.04773	-0.031

Estimates of the Mean Willingness to Pay

As mentioned before the sample size for which the analysis was carried out is 804. The sample median and mean are given in Table 6.6

Table 6.6 Mean Willingness to Pay Voluntarily and In the Form of Tax

	FINVOL	FINTAX
Mean	537.85	219.17
Median	241.00	29.50

A large difference in the mean and median values is observed. The sample median is usually used to provide a measure of central tendency in cases like these where the sample is highly skewed to the left owing to extraordinarily high outliers.

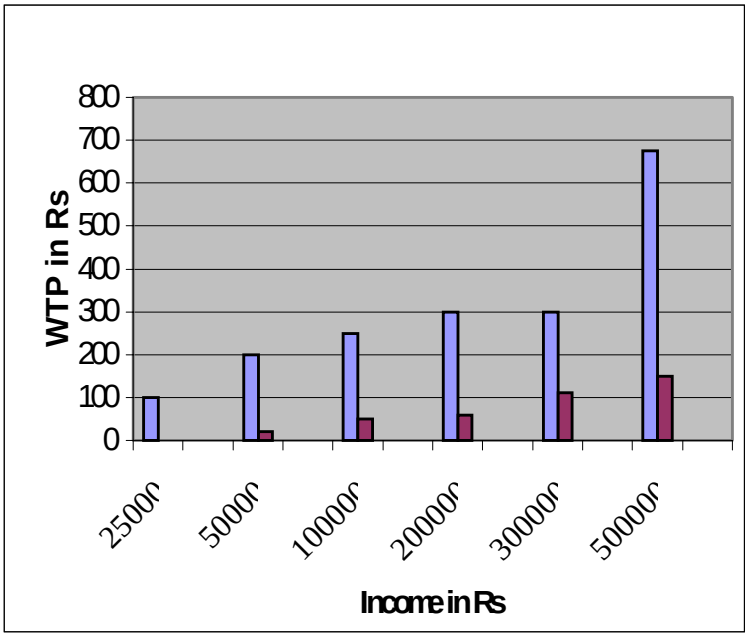
The influence of various factors on the mean willingness to pay has been studied as per the following heads:

Income:

Income has a significant correlation with both the voluntary WTP as well as the Taxation WTP. It is found on observation that with rising incomes the average means also go on increasing as is evident from Table 6.7 below:

Table 6.7 WTP As Per Income

INCOME		FINVOL	FINTAX
25000	Mean	202.01	75.00
	N	128	128
	Median	100.00	.00
50000	Mean	370.91	143.11
	N	217	217
	Median	200.00	20.00
100000	Mean	529.15	229.66
	N	215	215
	Median	250.00	50.00
200000	Mean	792.55	325.76
	N	165	165
	Median	300.00	60.00
300000	Mean	941.54	351.35
	N	52	52
	Median	300.00	110.00
500000	Mean	1232.69	536.15
	N	26	26
	Median	675.00	150.00
Total	Mean	537.85	219.17
	N	803	803
	Median	240	30



Graph 6.1 WTP As Per Income

Length of Residence:

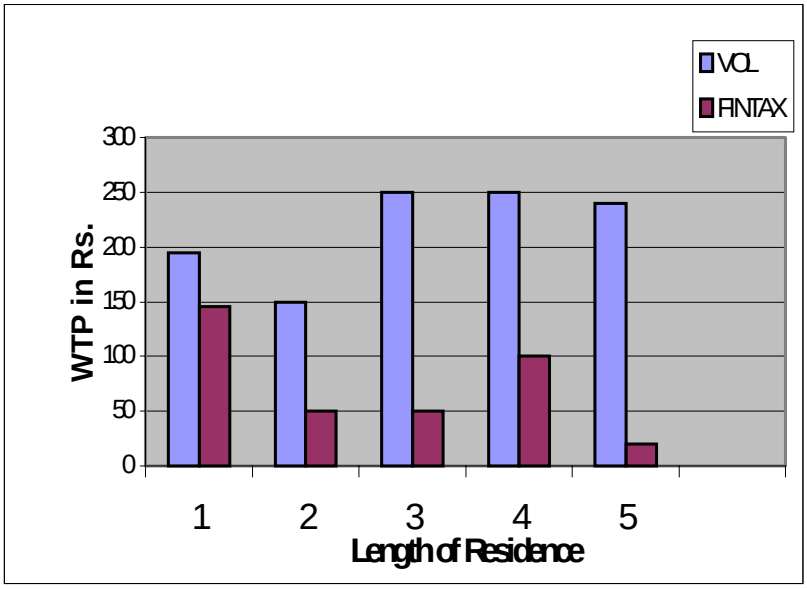
Length of residence has been divided into the following categories –

Less than 1 year - 1
1-5 years - 2
5 – 10 years - 3
10 – 20 years - 4
more than 20 years - 5

The correlation for this factor with the voluntary WTP and the WTP as tax is not significant. On the other hand the means are as in Table No. 6.7:

Table 6.8 WTP As Per the Length of Residence

LNTRES		FIN VOL	FINTAX
1	Mean	454.17	236.67
	N	12	12
	Median	195.00	145.00
2	Mean	433.94	175.53
	N	47	47
	Median	150.00	50.00
3	Mean	426.10	218.54
	N	41	41
	Median	250.00	50.00
4	Mean	708.52	277.10
	N	105	105
	Median	250.00	100.00
5	Mean	525.39	212.39
	N	597	597
	Median	240.00	20.00
Total	Mean	537.85	219.17
	N	803	803
	Median	240.00	30.00



Graph 6.2 WTP As per the Length of Residence

From the above table it can be seen that the average mean shows a decrease in the voluntary WTP with increase in the stay of residence in the city initially. The maximum WTP is for people who have stayed in the city for 10 – 20 years. Then the mean begins to fall again. It is least for people who have lived in the city for around 5 to 10 years. For the WTP as tax, it is least for people who have lived in the city for between 1 year to 5 years. On the other it is maximum for people who have stayed in the city for 10 – 20 years.

Frequency of visits:

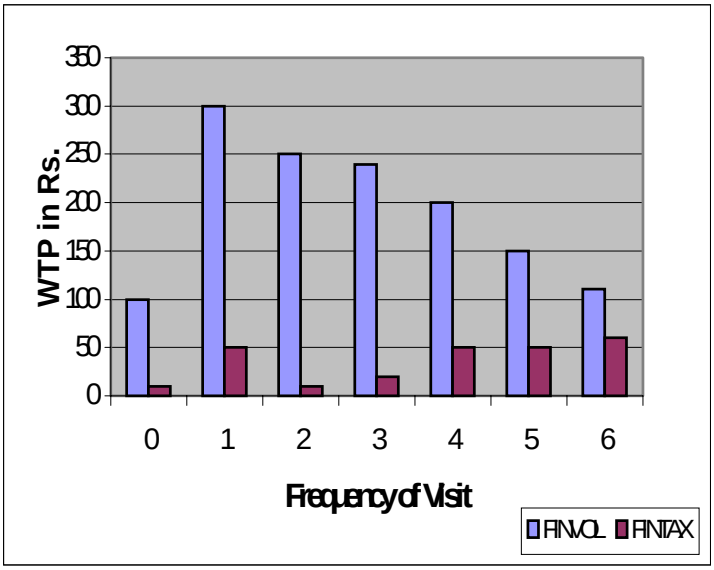
This factor has also been divided into categories such as given here –

Every week	-	1
Once in a fortnight	-	2
Once in a month	-	3
Once in two - six months	-	4
Once in seven - twelve months	-	5
Not at all	-	0

The correlation for this factor with the mean WTPs is once again not significant. The mean figures for the various time intervals of visits are given in Table No. 6.9:

Table No. 6.9: WTP As Per the Frequency of Visits

FREQUENCY OF VISIT		FINVOL	FINTAX
0	Mean	430.28	179.31
	N	36	36
	Median	100.00	10.00
1	Mean	731.76	295.40
	N	176	176
	Median	300.00	50.00
2	Mean	438.13	174.98
	N	87	87
	Median	250.00	10.00
3	Mean	487.70	178.30
	N	171	171
	Median	240.00	20.00
4	Mean	457.28	206.57
	N	187	187
	Median	200.00	50.00
5	Mean	561.31	231.36
	N	143	143
	Median	150.00	50.00
6	Mean	110.00	60.00
	N	2	2
	Median	110.00	60.00
Total	Mean	538.39	219.44
	N	802	802
	Median	240.00	30



Graph 6.3 WTP as per Frequency of Visit

From the above table it is obvious that the maximum willingness to pay is shown for people who visit the lakes most frequently. On the other hand the WTP for people who have never visited the lakes for recreational purposes is till quite high. But it is the lowest for people who rarely visit the lakes.

Concern of the people about pollution:

The aim of this analysis is to find out whether people who show high concern for pollution as a major problem faced by India today are willing to pay significantly higher amounts or not. The results are very typical of the way people quote things and actually behave. The categories for this particular were divided on a scale of 5 where 1 showed the maximum concern for environment as a major problem for the country and 5 the

least concern. The values of the mean WTPs for these concern levels are as in Table No. 6.10:

Table No 6.10: WTP As Per Concern of the People about Pollution as a Problem

Poll		FINVOL	FINTAX
1	Mean	599.35	222.87
	N	412	412
	Median	250.00	20.00
2	Mean	411.05	164.31
	N	245	245
	Median	200.00	50.00
3	Mean	553.14	315.86
	N	105	105
	Median	300.00	20.00
4	Mean	785.81	310.97
	N	31	31
	Median	300.00	120.00
5	Mean	181.00	111.00
	N	10	10
	Median	100.00	.00
Total	Mean	537.85	219.17
	N	803	803
	Median	240.00	30.00

Strangely enough, people who rank environmental pollution as only somewhat important for the country, are WTP the largest amount as voluntary payment. On the other hand as expected, the mean WTP both as voluntary payments and tax is least for people who do not consider environmental pollution of any importance for the country today.

Education level:

Education level of the people shows a significant enough correlation with both the WTP amounts. In other words with increase in education standards people are willing to spend more money on intangible benefits from the Lakes. The education level has been clubbed into the following categories:

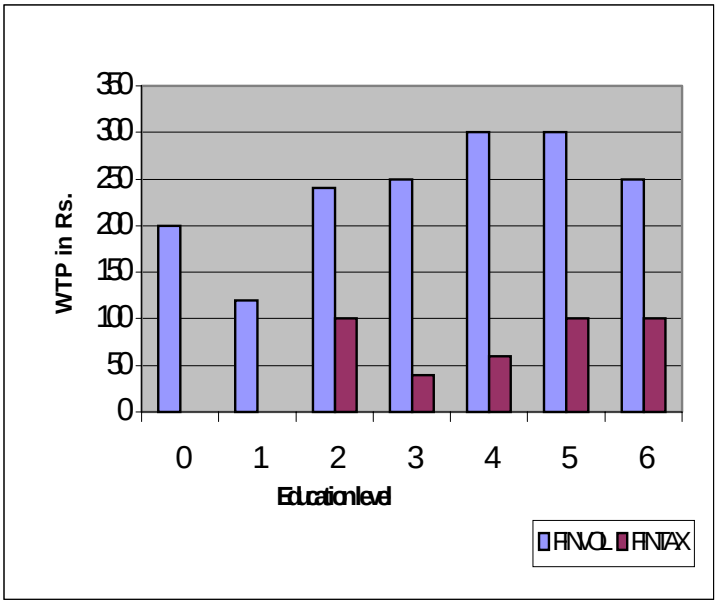
Illiterate	-	0
Below Class XII	-	1
Upto Class XII	-	2

Undergraduate (B.A./ B.Com/B.Sc) - 3
Postgraduate (M.A. / M. Com / M.Sc.) - 4
Professional Qualifications (B.E. / B. Tech. / M.B.A. / M.B.B.S.) - 5
Other - 6

The mean WTPs for the various education levels are as in Table No. 6.11:

Table No. 6.11: WTP As Per The Education Level Of The People

EDUCATION LEVEL		FINVOL	FINTAX
0	Mean	262.60	77.40
	N	25	25
	Median	200.00	.00
1	Mean	347.54	143.50
	N	259	259
	Median	120	.00
2	Mean	463.29	253.36
	N	70	70
	Median	240.00	100.00
3	Mean	560.67	187.74
	N	198	198
	Median	250	39.00
4	Mean	730.57	329.29
	N	143	143
	Median	300.00	60
5	Mean	912.56	356.52
	N	82	82
	Median	300.00	100.00
6	Mean	483.46	217.69
	N	26	26
	Median	250.00	100.00
Total	Mean	537.85	219.17
	N	803	803
	Median	240.00	30



Graph 6.4 WTP as per the Education Level

As can be seen from the Table the mean voluntary WTP increases with increase in education levels and is maximum for people who have a post graduate degree. The same is the case for the WTP as tax. This is to be expected as a higher education level can be assumed to lead to better understanding and concern for the system and then again a strong correlation between income and education also exists meaning that the better educated a person the more will be his income as is to be expected.

Occupation:

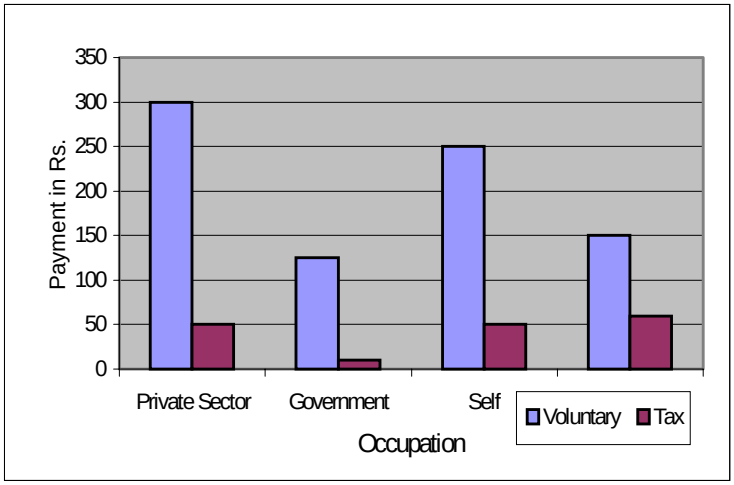
The various occupation categories have been divided as per the following:

Private Sector Employee - 1
Government Employee - 2
Self Employed - 3
Other - 4

The various mean WTPs for these categories of occupation are as shown in Table No. 6.12:

Table No 6.12: WTP As Per the Occupation of the People

OCCUPATION		FINVOL	FINTAX
1	Mean	492.46	255.86
	N	124	124
	Median	300.00	50.00
2	Mean	470.09	170.72
	N	292	292
	Median	125.00	10.00
3	Mean	596.06	232.91
	N	339	339
	Median	250.00	50.00
4	Mean	656.15	322.08
	N	48	48
	Median	150.00	60.00
Total	Mean	537.85	219.17
	N	803	803
	Median	240.00	30.00



Graph 6.5 WTP as per Occupation

The highest WTP as both voluntary and tax are for category 4 where we have people who are working as contractors or are still students and not employed. This means that with high income as in the case of contractors, the WTP is high and students who are still not independent are again WTP higher amounts than people with responsibilities are. The people who are WTP least both voluntarily and as tax are not surprisingly government employees! This says quite a lot for the attitude of these people who already feel loaded with the tax structure existing in the state and their reluctance to contribute because of these reasons.

Distance:

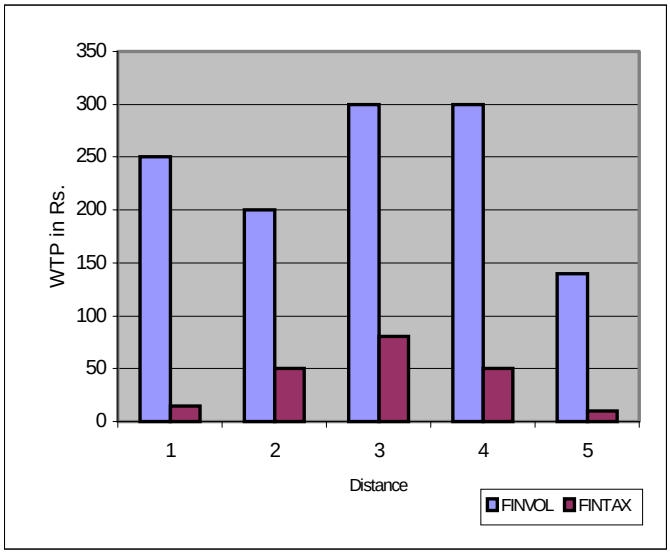
The distance at which people stay from the lake has also been expressed in the following manner:

Within a half mile radius	-	1
Between 0.5 – 1 mile	-	2
Between 1 – 1.5 mile	-	3
Between 1.5 – 2 mile	-	4
More than 2 miles	-	5

The mean values of WTPs for these distance ranges are as shown in Table No. 6.13:

Table No. 6.13: WTP According To Distance from the Lakes

DISTANCE		FINVOL	FINTAX
1	Mean	633.39	277.17
	N	166	166
	Median	250.00	15.00
2	Mean	467.35	190.51
	N	164	164
	Median	200.00	50.00
3	Mean	523.66	272.39
	N	134	134
	Median	300.00	80.00
4	Mean	655.98	261.11
	N	119	119
	Median	300.00	50.00
5	Mean	463.06	141.66
	N	220	220
	Median	140.00	10.00
Total	Mean	537.85	219.17
	N	803	803
	Median	240.00	30.00



Graph 6.6 WTP according to Distance

The mean WTP as voluntary payment is strangely highest for people who stay within a 1.5 to 2 mile radius of the Upper and the Lower Lakes but then again it is also significantly high for the people who stay very near the Lakes giving credence to the hypothesis that people staying near the lakes should have a higher regard for their value as compared to people who stay some distance away.

These then were the various sub analyses done for the entire city based on the most important socio-economic, attitudinal and geographical parameters.

Extrapolating the mean WTP for the entire city:

Since there is a large difference in the mean and median difference owing to the skewness shown by the sample, for a better representation of the estimated WTP, the median value for both voluntary WTP and the WTP as tax, is taken. Altogether there are 2,01,116 households in the city. Considering that the median voluntary WTP to be taken is Rs 241/- and the median WTP to

be paid as tax is Rs 29.50/-, the estimated WTP for the city is calculated and presented in Table No. 6.14:

Table No. 6.14: Estimated WTP for Entire City

Median FINVOL per household per annum = Rs 241.00/-	Total Number of households in City = 2,01,116	Total Voluntary WTP per annum = Rs 4,84,68,956/-
Median FINTAX per household per annum = Rs 29.50/-		Total WTP as tax per annum = Rs 59,32,922/-

There were a number of other very important observations that were made during the course of the survey. These are as follow:

People were asked to rank various problems facing the country as perceived by them. Table No. 6.14 contains the results obtained for the same:

Table No. 6.15: Ranking of Problems Facing the Country

Problems	Rank 1		Rank 2		Rank 3		Rank 4		Rank 5		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	
Corruption	592	74	121	15.13	61	7.63	15	1.88	11	1.38	800
Foreign infiltration	375	46.76	220	27.43	133	16.58	54	6.73	20	2.40	802
Pollution / Environmental degradation	412	51.31	245	30.51	105	13.08	31	3.86	10	1.25	803
Lack of a stable government	342	42.59	204	25.41	156	19.43	62	7.69	39	4.86	803
Economic Issues	400	49.14	213	26.53	136	16.94	34	4.23	20	2.49	803

Thus it can be seen that most of the people give maximum weightage to corruption as a national problem followed by environmental pollution and economic issues and so on. On the other hand a very small percentage of the people interviewed claimed pollution or environmental degradation as the least important problem.

Among all these environmental problems the various problems were ranked as given in Table No. 6.16:

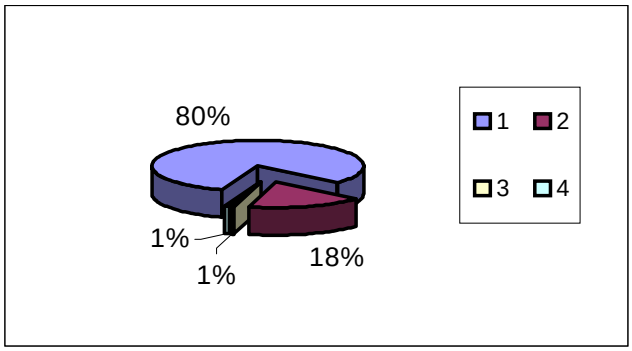
Table No. 6.16: Ranking Of Various Environmental Problems

	Rank 1		Rank 2		Rank 3		Rank 4		Rank 5		Total
	No	%	No	%	No	%	No	%	No	%	
Deforestation	501	62.4	186	23.2	80	10.0	28	3.5	8	1.0	803
Urban waste	421	52.4	231	28.8	118	14.7	23	2.9	9	1.1	802
Noise Pollution	167	20.8	220	27.4	298	37.1	87	10.8	31	3.9	803
Vehicular Pollution	289	36.0	246	30.6	196	24.4	54	6.7	18	2.2	803
Industrial Pollution	244	30.4	238	29.6	174	21.7	115	14.3	32	4.0	803

As per the people of the city who were interviewed, the biggest environmental threat in the country is deforestation followed by urban waste and vehicular pollution. Noise pollution is not considered to be as important a problem by the major portion of the population.

Most of the city's population obtains its drinking water from the Municipal Supply. The percentage of the sample obtaining its drinking water supply from various sources are as shown in the graph here.

Graph 6.7 Drinking Water Sources in Bhopal City



The legends stand for the following:

1 – Municipal Supply

2 - Tube Wells

3 - Tankers

4 – Dug wells

Thus 80 per cent of the sample interviewed obtained their drinking water from the municipal supply, 18 per cent from tube wells, and one per cent each from tankers and dug wells.

The water purification techniques used by the people were also studied. The results of this are presented in the Graph 8. The legends shown therein stand for the following:

Graph 6.8 Water purification Techniques followed in Bhopal City

1 – Aquaguard

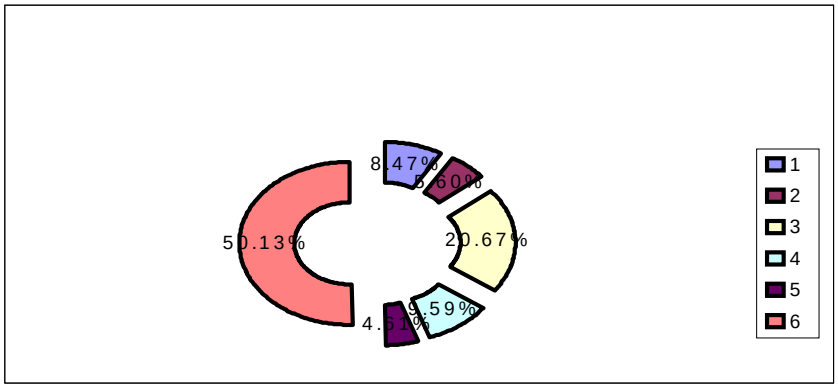
2 – Zero B

3 – Ordinary Filter

4 – Chlorine / Alum

5 – Boiling

6 – None



Thus nearly 51 percent of the population does not use any water purification measures, while nearly 21 percent use ordinary filters and only 8.5 per cent use Aquaguards and 5.6 per cent use Zero B.

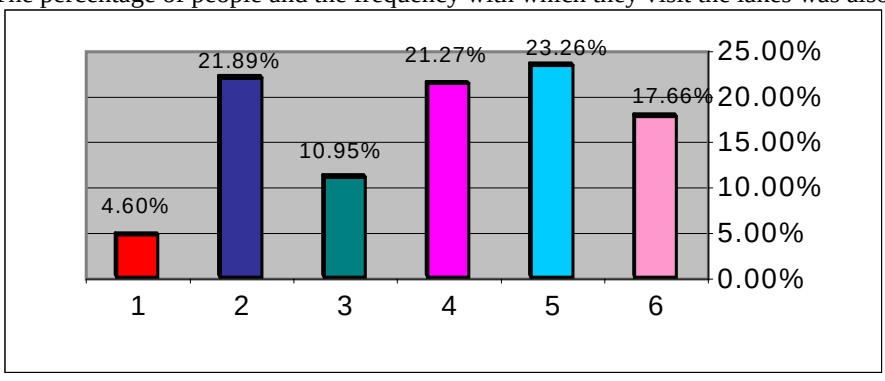
The people were also asked to rank a few services that are obtained from the Bhoj wetland as per their attitude. The results obtained were as given in Table No. 6.17:

Table No. 6.17: Ranking Of Various Services Obtained From The Bhoj Wetland

Services	Rank 1 (%)	Rank 2 (%)	Rank 3 (%)	Rank 4 (%)	Rank 5 (%)
Drinking Water	82.0	8.6	5.3	2.5	1.6
Stability of Microclimate	30.8	35.0	23.5	6.8	3.9
Employment	25.7	21.8	28.4	16.8	7.3
Recreation	37.6	26.7	23.3	8.6	3.9

From the Table it is evident that the maximum number of people consider drinking water to be the most important service obtained from the Bhoj Wetland. The next highly rated service was recreation, followed by stability of microclimate and employment was rated last, showing that fewer people found it important as compared to the other services.

The percentage of people and the frequency with which they visit the lakes was also calculated. The observations are shown in Graph 9: Graph 6.9 Frequency of Visits to the Upper and Lower Lakes



X Axis: Frequency of visits

1 – Not at all

2 – Every week

3 – Once in a fortnight

4 – Once in a month

5 – Once in six months

6 – Once in a year **Y-Axis: Percentage of people visiting the lakes**

From Graph 9 it is evident that nearly 41 percent of the population visits the lakes quite infrequently, from once in six months to once in a year. Quite a significant number visit it every week even though they might be living at quite a distance from the lakes.

There are a number of problems that plague the Lakes and threaten its very existence. The attitudes of the people and their opinions about the effects of these threats was also studied. These are presented in Table No. 6.18:

Table No. 6.18: Ranking Of Various Threats To The Bhoj Wetland

Threats	Rank 1 (%)	Rank 2 (%)	Rank 3 (%)	Rank 4 (%)	Rank 5 (%)
Siltation	40.8	24.6	20.4	7.8	6.3
Solid Waste	63.9	24.4	9.0	1.6	1.1
Sewage	77.9	14.4	5.2	1.9	.6
Washermen	35.6	29.4	20.5	8.8	5.7
Trapa cultivation	15.2	19.9	23.8	16.9	24.1
Encroachment	43.7	23.1	19.0	8.2	6.0
Increasing population	47.4	19.8	13.4	9.8	9.6
Weeds & Eutrophication	44.2	25.9	17.7	6.5	5.8
Boating	6.0	9.0	14.8	13.3	57.0
Agricultural Waste	13.8	17.4	22.5	17.3	28.9
Idol Immersion	44.7	22.9	13.1	8.0	11.4
Hospital Waste	82.6	9.2	4.2	1.9	2.1

From Table No. 6.18, it can be seen that according to the people, the most important threats to the Lakes are from hospital waste, sewage and solid waste, while the least threat perceptions are for boating activities, cultivation of *trapa* and agricultural wastes that flow into the Wetland.

Most people in the valuation exercise quoted sums that can be considered to be underpayments and as much has been admitted by the people themselves. This is mainly because imagining such a scenario as created, for the people is tough. On the other hand, most people were sceptical about the role of government when involved in the management body. They were willing to pay more but only once the body came into being and had proved itself capable of working efficiently and smoothly.

6.4. Hedonic Pricing

This is the last valuation exercise that has been carried out in this study through which it has been attempted to calculate by what proportion closeness to the Upper Lake affects property prices. This was studied in two steps. In the first step attitudes of the people were studied as to what importance they give to particular factors while buying a piece of property. In the second step some property prices in particular areas in the city were obtained and then these areas were ranked against parameters of neighbourhood, proximity to markets, ease of access, environment, housing density and presence and absence of lake. A regression model was created for this equation and from that the effect of presence of lake on property prices was gauged.

For the first step, the opinion of the people regarding the following 15 parameters was calculated using Multi Criteria Analysis and the DEFINITE software. As mentioned earlier that the Multi Criteria Analysis is a non-monetary evaluation method which tries to capture value of goods and services or factors through ordinal ranking method in the absence of market. Values attached to different factors of property by the buyers are analysed using MCA to arrive at appraisal scores attributed to different aspects of value. The various appraisal scores obtained thus are expressed in the Table No. 6.19:

The table shows that in the preference of various factors considered by the prospective buyers while buying a new property, existence of lake receive low preference whereas availability of drinking water, safety, existence of school for children, nature of property itself are the major determining factors. The reason for low preference for location near or in front of lake is due to the fact that not many new properties are under construction as such due to lack of availability of vacant land. But the property prices of existing houses fetch high premium when they are resold. This factor is duly explained in the next step.

Table No. 6.19: Ranking Of Various Factors Considered while Buying Property

S. No:	Factor	Scores
1.	Drinking Water	0.99
2.	Safety	0.94
3.	School Quality of Construction Hospital	0.88 0.87 0.87
6.	Age of House	0.85
7.	Park Market Air Pollution	0.80 0.79 0.79
10.	Work Place	0.77
11.	Density Noise Pollution	0.70 0.70
13.	Lake	0.67
14.	Household Help	0.56
15.	Road	0.31

The second step involved the formation of a regression equation to express the various factors affecting the price of property in the city. The various factors taken into consideration for this purpose are:

1. **Neighbourhood** – All the sites taken into consideration in the study were ranked on a scale of 1 to 5 for this parameter where 1 stood for the best neighbourhood and 5 for the worst. A good neighbourhood meant a higher-class posh locality with all civic amenities while a bad neighbourhood signified an unsafe, area with poor facilities available.

2. **Market** – This parameter was again ranked on a scale of 1 to 5 where rank 1 was given when a site was very close to a good market and rank 5 was given when the place was far away from a good market.

3. **Access** – This signified the ease of accessibility for each site. When the area was close to the centre of the city it was given a rank 1 but when it was far away from the heart of the city it was given a lower rank.

4. **Lake** – The Lakes were treated as a dummy variable. When a site had the lake in close vicinity, it was given a rank of 1 and when the lake was no where near the lake it was given a rank of 2.

5. **Environment** – This factor meant a congenial, pleasant atmosphere in the locality where the site was situated taking into account the presence of sanitary conditions, cleanliness, parks and ample open spaces. Sites where all of these were present were ranked at 1 and the others were given lower rank as per the conditions present there.

6. **Housing Density** – This factor referred to the number of houses in a particular location and how crowded a particular area was. Very dense areas and similarly extremely isolated areas were equally given low ranks while optimally populated areas were ranked at 1.

The regression equation was formed taking all these factors into consideration. Thus the equation formed for this was expressed as:

P = *f* (constant, neighbourhood, market, access, lake, environment, housing density)

where P = property price in Rs/sq ft and the other factors as described above.

The equation was thus of the form:

$P = \alpha + \beta_1 NEIGHBOURHOOD + \beta_2 MARKET + \beta_3 ACCESS + \beta_4 LAKE + \beta_5 ENVIRONMENT + \beta_6 HOUSING\ DENSITY.$

The estimation results came out as in Table 6.20:

Table No. 6.20: Estimation Results of Hedonic Pricing

Dependent Variable = Price in Rs/sq.ft Number of Observations = 27 R squared = 0.781 Package Used = SPSS 10.0		
Variable	**Coefficient**	**t - statistic**
CONSTANT	-607.596	-3.883
NEIGHBOURHOOD	282.739	4.591
MARKET	-112.570	-1.661
ACCESS	101.902	1.575
LAKE	185.896	2.518
ENVIRONMENT	111.047	2.097
HOUSING DENSITY	-67.203	-1.379

From the above table, it is found that all of the coefficients taken in the equation are significant as per the tests run on them. For establishing the relationship between price in Rs/sq.ft and presence of the lake a partial correlation test was run and the value of this came out to be 0.495, adjusting for all the other parameters. Thus it can be said that for a property site near the lakes the difference in property price would nearly be 50%.

That is a site similar in all other respects to a site away from the lakes would be exceeding the latter property by nearly 50 per cent in price.

Concluding Remarks: Multiple Values from Bhoj Wetland to Multiple Stakeholders

Different kinds of values accrue from the Bhoj Wetland to different stakeholders living around as well as away from the lake. The values so estimated using various valuation techniques are summarised in Table 6.21.

It could be seen that supply cost which is mainly incurred by the authorities to provide water to nearly half of the city's population is considerably high. Whereas the charge collected against it is low. Considerable income is also earned by individuals engaged in various economic activities like harvest of fish, *trapa*, boating and others. The environmental health of the Bhoj Wetland gets duly reflected in prevalence of water borne diseases. Water purification cost incurred by individuals is a reflection of people's willingness to pay for obtaining pure water. Lake front property owners do get a benefit of prevalent premium on their properties for this location. 50% of the price differential exist due to this factor. So far as preference of people for buying new property is concerned the factor of existence of lake ranks low as there is less scope for new properties to come up in front of lake due to lack of availability of land in the area. Since the entire lake is used for recreational purposes by the entire population, people seemed to be willing to make voluntary payment for its conservation as the people think that if the money so contributed to a society comprising of multiple stakeholders, the funds shall be used for the rightful purpose. Less willingness was shown in terms of tax payment because of uncertainty of use of that money when it goes in the hands of the government. But the thing is that there is lot of concern of the people for proper management of the Bhoj Wetland.

Thus the exercise presented above demonstrates substantial generation of values in term of actual use values and shows high dependence of people for various uses of Bhoj Wetland. The stakeholders show high awareness towards threats to the wetland as well as need to eliminate these threats for sustainable management of the wetland.

The understanding for their high stake in the wetland could rightfully be used if various sustainable management activities carried out in participatory manner.

Table 6.21 Estimation of Economic Values of Bhoj Wetland (Annual for 1999-2000)

Uses / Impacts	Stakeholders	Valuation Techniques	Value (in Rs)
A. Drinking Water	Water supplying agencies	Supply Cost	9,54,13,962
B. Fish Production	Fishermen	Market Price of Existing Production	49,20,000
C. Boating	Boatmen	Income Estimation	24,37,880
D. *Trapa* cultivation	*Trapa* (water chest nut) Cultivators	Market Price of Existing Production	50,00,000
E Washing of clothes	Washer men	Income Estimation	36,00,000
F. Secondary Activities i. Maize cob selling ii. Sugar cane juice selling iii. Snacks &cold drink stalls iv. Horse rides v. MPTDC a. Cafeteria b. Boating	 i. Maize Cobb sellers ii. Sugarcane juice sellers iii. Individual owners iv. Individual owners v. MPTDC	 i. Income Estimation ii. Income Estimation iii. Income Estimation iv. Income Estimation v. a. Revenue Generation b. Revenue Generation	 i. 1,44,000 ii. 2,73,600 iii. 2,06,400 iv. 7,92,000 v. a. 18,00,000 b. 6,74,635
G. Water borne Diseases	Population using lake's water	Cost of Illness	12,00,254
H. Quality water	Population using lake's water	Purification costs	1,24,35,876
I. Recreation	Entire population of the city	CVM (voluntary Payment)	4,84,68,956
J. Increase in property prices	Lake front property owners	Hedonic pricing	50% difference in property prices

CHAPTER VII : CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE MANAGEMENT STRATEGIES

7. 1 Conclusions from the Bhoj Wetland Valuation Exercise.

7.1.1. Values and Stakeholders in Bhoj Wetland

Sustainable use of wetland resources that too located in urban areas with high population densities poses a number of challenges. The challenge becomes even more difficult where there are multiple values and multiple stakeholders. Bhoj Wetland (BWL) located in the heart of Bhopal city is a unique example of an urban wetland. It is rightly considered as 'the lifeline of the Bhopal city'. Constructed as a major source of drinking water, now it also provides recreational and productivity benefits and at the same time used as a 'sink' for the purpose of throwing wastes of various types. It has now become a glaring example of misuse of 'a common property resource'. The Bhopal Municipal Corporation(BMC) is a major stakeholder in terms of the maintenance agency whereas the ongoing water quality restoration activities and prevention of pollution are undertaken by the Environmental Planning and Co-ordination Organisation (EPCO) of the Housing and Environment Department of Govt. of M.P. In this sense the government agencies are major stakeholder responsible for maintaining the ecological health of the Bhoj Wetland such that economic and ecological benefits continue to accrue. The stakeholders deriving the benefits are the general population of Bhopal city for recreational benefits, lake front property owners on account of aesthetic value and micro climatic effects of lake, various communities dependent for their livelihood like fishermen, trapa cultivators, boatmen, washer men and sellers around the lake.

7.1.2 Threats to Bhoj Wetland

Being an urban wetland and having prolific colonisation around it, the environmental health of Bhoj Wetland has been degrading over the years. The failing ecological integrity is also impacting the economic activities. The threats are due to anthropogenic activities and are identified as siltation, solid waste pollutants, sewage, washing

activities, trapa cultivation, encroachment, weeds and eutrophication, boating (excessive) agricultural waste idol and tadjia immersion, hospital waste etc.

7.1.3 Estimation of Values Accruing from BWL

BWL provides many uses which lead to many economic benefits to meet the spectrum of wants and needs of multiple stakeholders ranging from very tangible subsistence uses like drinking water, fish production, trapa etc. to intangible psychological needs like aesthetic beauty and recreation. It could be seen that some of these uses are direct uses with significant extraction like water supply, fish production, trapa cultivation. There are some direct uses but are non extractive like ecotourism, recreation and these could also have vicarious uses for media such as magazines & films. The indirect uses also exist for the entire population living around or close to lake as it benefits from the complex ecological functions of the lake which supports economic activity and human welfare. As mentioned above that besides providing drinking water & livelihood to many people through provision of various resources, the BWL also acts as 'sink' to the waste which is put by the adjoining population in the form of sewage, detergents, solid waste, hospital waste, silt flow, agricultural run off to name a few. It processes these wastes through nutrient cycle, filtration etc.

Other indirect uses are carbon fixing, micro-climatic effects, habitat for migratory birds. Though the BWL is a provider of many such values but more so it is used as a CPR and has been facing increasing pressure due to increasing anthropogenic activities. Many uses are directly extracted and do not enter into market. People do have use values but are not aware of market values of such uses. Even though in some cases market price could be traced (which mainly accrues to individual stakeholder) but there are no supply costs attached to it. To capture all such values, the valuation exercise has been attempted and Ramsar's Guide for Policy Makers & Planners on "Economic Valuation of Wetlands" (Barbier et.al. 1997) has been used as main tool to attempt this valuation exercise besides drawing from many other sources.

In the valuation exercise attempted here the actual use values accruing to various stakeholders are estimated using alternative methodologies like :

ii. Supply cost technique is used to estimate actual value of water supply, which is otherwise highly undervalued commodity as the water tax is very low.

iii. Market price of existing production of fish and trapa was used to express the value for fishermen and trapa cultivators. Due to lack of information on changes in productivity stemming from modification in BWL value of the existing production is considered.

iv. Income estimation approach is used to capture the value accruing to boatmen, washermen, and sellers of various edible items and joyrides undertaking activities in and around the lake.

v. Revenue generation has been administered to arrive at values accruing to MPTDC for running the Cafetaria and boats.

vi. Cost of illness technique has been used to measure the extent of damage to the health of wetland ecosystem in terms of its linked impact on human health.

vii. The abatement cost method captured the cost of purification of water so as to reflect the willingness to people to pay to obtain pure water.

viii. All the above techniques tried to capture the values for individual users but the entire population for the purpose of recreation uses the lake. CVM has been used to capture the willingness of people in terms of voluntary payment on tax to conserve the lake for recreational purposes.

ix. Hedonic pricing was used to capture indirectly the premium prevalent in property prices due to their location over the lake.

x. Multicriteria techniques tried to capture the preferences of buyers while considering property purchases.

The valuation exercise revealed that high supply cost is borne by the authorities whereas the revenue earned in exchange is very normal. Income earned by individuals showed high economic dependence of certain class of people on the lake. The value of lake's deteriorating quality was reflected through willingness of people to pay for water purification and the cost that they are bearing on account of water borne disease. People showed high WTP for conserving the lake for recreational purpose. The population of Bhopal city is WTP Rs. 4,84,68,956/- anually (Rs. 241/- per household) as voluntary payment forwards Bhoj Wetland Management Society and only Rs. 59,32,922 annually (Rs. 29.50 per household) if it is taken as tax. Nearly 95% of the sampled population visit lakes mainly for the purpose of recreation. They at the same time showed high awareness for various threats. In property price approach also it was found that aesthetic value of lake commands a high premium in case of existing properties but in the purchase of new property by people other factors like availability of drinking water, safety, various neighbourhood and accessibility factors gain more importance.

7.1.4 ***Restoration Activities for BWL***

There are a number of restoration activities being carried out by the State Government in the Upper and the Lower Lake which are aimed at restoring and maintaining the water quality and the quantity in the Lakes. This project is not only expensive but quite ambitious and the only one of its kind to be introduced in a freshwater wetland in India. As a result it has brought widespread recognition and appreciation to the agencies implementing it (dealt in Chapter II).

7.1.5 ***Ecosystem Modelling of BWL***

Ecosystem Modelling has been attempted to study the past, present & future scenarios of the lake. Various water quality parameters have been used here which are important from the point of view of various economic values that are derived from the lake base on ecological integrity of the BWL's ecosystem. The valuation exercise attempted was used to indicate the overall economic efficiency of the various competing uses of this wetland resource. Further through modelling exercise the linkage between the ecosystem's health and the health of the economic system and also vice-versa has

been established. A major difficulty that the wetland valuation exercises face is on account of complexity of such environmental systems due to insufficient information on important ecological and hydrological processes that underpin the various values generated by the wetlands(Barbier et.al. 1997). Through ecosystem modelling exercise an attempt has been made to understand such ecological and hydrological processes using only water quality parameters which greatly determine the potential of economic values from the BWL ecosystem. It also contributes towards prioritization of wetland uses as there are inherent conflicts or tradeoffs amongst them. For instance, it may not be possible to manage BWL for drinking water or recreation or fishing while at the same time using it as a sink for wastes of various kinds for their treatment. Further this exercise compares PDL and ongoing restoration activities and projects. The status of two lakes expressed through the modelling exercises could be used as an input by the policy makers to prioritise various interventions for the wise use of Bhoj Wetland.

7.1.6 ***Policy Implications from Valuation & Ecosystem Modelling***

After the restoration project is over, the maintenance of this Wetland is supposed to pass into the hands of the Bhopal Municipal Corporation who have looked after these lakes till now. But this project and the results that are expected to be achieved from it would fail miserably if the lakes were not maintained in the future in the same way. Such expensive restoration activities cannot be carried out every now and then but can be said to be a one time effort actually. The sustainability of this kind of an effort is obviously under considerable strain if the factors that were responsible for causing its degradation in the first place, are not checked. For this purpose involvement of the community becomes very necessary. Unfortunately, the people have not had anything to do with this project till now. The awareness levels among the general population about the details of this project are astonishingly low, considering the detailed publicity and campaigns carried out in the city via popular media.

Secondly, sustainability is an issue that has been much debated in the past. Sustainability as defined in general terms means use of a resource in a manner that provides not just for the needs of the current generation but also leaving enough to

meet the needs of the future generations. Thus it talks not only about intra generational but inter generational equity. Sustainability implies a balancing of economic benefits with resource availability/replenishment and environmental costs of growth. But there are problems with this sort of balancing. How much of use is good and when does it become unsustainable? Again, how much should be left for our future generations and how much should be consumed by this generation? All these questions are difficult to answer and estimates are tough to arrive at.

The above problems of the Upper and Lower Lake have arisen due to unsustainable use of this scarce resource - drinking water. Drinking water is the primary need of a growing city and pollution of its source produces a grave threat not just to the ecosystem but also to the health of the citizens in the city. Therefore care has to be taken to look after this resource and maintain its sustainable use in the future.

But is this enough for sustainable development? How can development without participation from the people be envisioned? Thus for development to fulfil its long term objectives, it becomes necessary to ensure that it is of the people, for the people and by the people. Unless people themselves come to realise the need for improvement and maintenance of the resources, their misuse cannot be curtailed be it for the Bhoj Wetland or some other natural resource like forests, pasturelands, etc. Thus it becomes necessary to plan development in a manner that it does not alienate people but makes them part of the system. And this is what is exactly required for the continued flow of benefits from the Bhoj Wetland. Awareness about the problems and empathy for the system have to be created not by holding sporadic and ineffectual awareness campaigns but through building local participation and support by making them part of the decision making process. This is possible only when a certain responsibility towards the ecosystem is felt by the people, which in turn is possible only when the actual value of this resource is known to them. The value worked out in this study should be of use to the policy makers and city planners in working out future management strategies for this important wetland resource (Verma and Bakshi, 2000).

7.2 Recommendations for Future Management Strategies: Lessons from Valuation & Ecosystem Modelling Exercise.

There are many ways of managing a resource. Two of the extreme ways by way of example are total conservation and open use. Now, both of these are impractical and impossible to allow, the first because the Wetland is a way of life for many people and their entry just cannot be banned without reason; the second because it would lead to the Wetland becoming a common property resource with common access and share the fate that has happened to many others. Examples are abounding of water bodies which have dried up due to human activities in their catchment area or they have been filled up to create more land to be sold as plots. According to Garrett Hardin, freedom in a commons leads to the 'Tragedy of the Commons', where each individual in his partial rationality tries to maximise his gains and thereby rushes towards ruin. He also adds that the air and water around us cannot be fenced, and so the tragedy of the commons as a cesspool must be prevented by different means, by coercive laws or taxing devices that make it cheaper for the polluter to treat his waste than to discharge them untreated. Working along this line of thought, it makes sense to charge people for not just the sewage that people put into the water but also the drinking water that they use. The current tax rates are not even enough to look after the maintenance of the pipelines used in water distribution. The water tax should be altered at differential rates for people according to their ability to pay. Otherwise, water metres can be introduced and the people should be charged according to what they actually use. This ought to lead to some sort of social responsibility among the people whereby they would control their use of the resource, drinking water in this case**.**

In light of the above mentioned valuation & ecosystem modelling exercises which were brought about through extensive personal discussion, focal group meetings, secondary data through various departments and stakeholders workshops (Annexure III), a set of technical and policy recommendations are proposed to operationalize the objectives of the study leading to analysing the factors causing Bhoj Wetland degradation; nature and extent of injury to the wetland; How does this degradation impact on the uses that citizens of Bhopal extract out of it ? What cost is borne by the users on account of

degradation in terms of productivity losses and health impacts? How feedback can be taken from these impacts to revise or develop management policies and to seek participation of stakeholders to check wetland degradation or losses? What is the willingness of the people to pay to conserve this wetland? The following set of Technical and Policy recommendations are proposed:

I Technical Recommendations

As the restoration activities are going on & shall take another year or so to complete and their impacts could be rightly assessed only after their complete execution. At the same time has been observed that the restoration and prevention activities have not been taken up in sequential manner. Thus it is necessary to follow stepwise physical interventions to restore the status of both the lakes of the Bhoj Wetland. The following are suggested to effectively implement the restoration subprojects:

i. It becomes necessary to first bring the preventive measures into working order before implementing what are known as the corrective measures. If the former are not implemented at the right time, the effect of the latter cannot be of any consequence. For example, floating fountains have been put up in the Lower Lake at huge costs without first of all completing the garland drain project which would stop the sewage from entering the Lower Lake. As a result sewage continues to flow unabated into the Lower Lake and at the same time, the floating fountains are supposed to aerate the Lakes. Naturally, the effect of the latter cannot be observed unless the flow of sewage is stopped.

ii. Retghat –Lalghati road has been constructed on the left bank of the Upper Lake , which is supposed to act as barrier to prevent encroachment but sewage through neighbouring colonies still continue to flow underneath.

II. Policy Related recommendations:

The critical need today is to recognize the inter-linkages and benefits that could be obtained if the wetland is managed in 'integrated manner' and is 'sustainably used'. It is a very challenging task and requires actions at many levels and delicate integrity of diversity of issues and management institutions. Such an approach must begin with involving all stakeholders in the wetland in the form of a local area institution, which shall be helpful in eliciting their views for use and future management of the Bhoj Wetland. The Institution so formed could frame the action plan to cover all ecological, economic, social and institutional issues. To cover the above issues the following set of policy recommendation is proposed :

a. It is imperative to take into account the perceptions of the people before carrying out any management exercise and especially one of this scale and to also involve the people at every stage of the planning process.

b. The management of the Lakes looks at the restoration and maintenance from each and every side. For this effective co-ordination between all the line departments that are connected with the use or maintenance of the lakes becomes necessary.

c. There needs to be more transparency in the system. When huge amounts of public money/funds are used for development activities, it becomes the responsibility of the concerned authorities to reveal to the people how the funds have been used.

d. There is need of setting up of a **Bhoj Wetland Management Committee** which should comprise of all the concerned line departments, such as the Public Health and Engineering Department, the Municipal Corporation, the MP State Tourism Department, research institutes like the Regional Research Laboratory, Indian Institute of Forest Management, Limnology Department of Barkatullah University, journalists, NGOs, representatives of the people through members of various residential or commercial societies, the fishermen society and the *dhobi*

community and maybe even people from religious groups. This body should be vested with all the decision making powers as far as the management of the Lakes in the future goes. The functions of the society would be to ensure maintenance and management of the Bhoj Wetland for Sustainable Use. The structure of Bhoj Wetland Society is given in Annexure V.

e. The valuation of the Lakes should serve as an important basis for designing of future strategies. It would also give an idea of the kind of money required for maintenance activities in the future.

f. The people are willing to pay substantial amounts for enjoying recreational benefits from the lake. This exercise should be followed by an actual collection exercise and that money would serve as the corpus of the Bhoj Wetland Management Committee. The figures so estimated by the Bhoj Wetland Department for the purpose of maintenance of sub projects after their completion roughly stands Rs. 80,70,000 (details in Annexure VI)If a 'management fund' is generated through the collection in terms of voluntary payment, the maintenance activities could be carried out smoothly.

g. A cost benefit exercise needs to be carried out once all the values have been calculated. This exercise taking all social costs and benefits into account would provide a picture of how effective the restoration programmes have actually been.

h. It is necessary to promote eco-tourism in the city. The city has two picturesque lakes which can provide an excellent site for adventure tourism as well. This would provide employment to a large number of people and would also bring the much required revenue into the coffers of the government. For this purpose, the Lower Lake and the Spill channel of the Upper Lake are wonderful sites. Sports like sport fishing, para sailing and para gliding, water scooters, yatching and many more can be introduced at these sites. Bhopal could soon figure on the international map for water sports provided the sports and the tourism ministry take up this challenge seriously.

i. There are a number of sites in the city area on the Idgah Hills and Shyamala Hills that provide a beautiful view of the Lake. If these sites can be developed as view points, they can become wonderful picnic sites. It is necessary to take up the development of these sites on a priority basis since land at these prime locations is the target of encroachments.

j. It is also important for all the concerned departments to prioritise their activities according to the simulation runs of the model for both the lakes. These models depict the scenario as in the past, present and as expected in the future at the following trends. Thus the effect of any management decision can be studied by using this model and this becomes extremely necessary for the effective implementation of the project.

It is believed that the recommendations listed above, if taken care off by management authorities shall help in economically wise, environmentally sound and socially acceptable process for sustainable management of such an important ‘Urban Wetland’

GLOSSARY

Alkalinity: It is inverse of acidity. A quantitative measure of water's capacity to neutralize acids. Alkalinity results from the presence of bicarbonates, carbonates, hydroxides, salts and occasionally of borates, silicates and phosphates. Numerically, it is expressed as the concentration of calcium carbonate that has an equivalent capacity to neutralize strong acids. Alkalinity higher than 200 mg/l make the taste of water unpleasant.

Bacterial Count: Maximum probable number (MPN) count of bacterial colony in a given water sample shows the total bacterial count. Measured the number of colonies per 100 ml of sample. Drinking water standards of World Health Organization (WHO) insists total absence of colonies in drinking water.

Bio-chemical Oxygen Demand: Biological uptake of molecular oxygen for the degradation of organic and inorganic compounds in the water. A maximum permissible limits of 25 mg/l BOD is given in WHO standards

Contingent Valuation: A valuation from a survey technique using direct questioning of individuals to estimate individuals' willingness to pay.

Direct Use Value: The value derived from direct use or interaction with a wetland's resources and services, such as the value of fish catches.

Dissolved Oxygen: Molecular oxygen dissolved in water from atmosphere and photosynthetic activities of primary producers. Temperature, turbidity and photosynthetic activities controls Dissolved oxygen value. Low value shows less primary production and high metabolic consumption. Unit is milligrams per liter of sample(mg/l). No. limits to drinking water standards but a minimum 4 mg/l is necessary for aquacultural activities.

Eutrophic: From Greek for "well-nourished", describes a lake of high photosynthetic activity and low transparency.

Eutrophication : The process of physical , chemical ,and biological changes associated with nutrient , organic matter, and silt enrichment and sedimentation of a water body. If the process is accelerated by man- made influences, it is termed cultural eutrophication.

Indirect Use Value: Indirect support and protection provided to economic activity and property by the tropical wetlands' natural functions, or regulatory 'environmental' services, such as flood alleviation.

Intrinsic Value: The worth of something in itself regardless of whether it serves as an instrument for satisfying individuals' needs and preferences.

Market: A collection of transactions whereby potential sellers of a good or service are brought into contact with potential buyers and the means of exchange is available.

pH: A measure of the concentration of hydrogen ions of a substance, which ranges from very acid (pH=1) to very alkaline (pH=14) . pH 7 is neutral and most lake waters range between 6 and 9. pH values less than 6 are considered acidic and most life forms can not survive at pH of 4.0 or lower.

Phosphates: Total organic and inorganic phosphate present in water sample. Organic phosphate is the chemically bound phosphate with living cells and inorganic or orthophosphate is absorbable form of nutrient. High phosphate value leads high organic production because it is the limiting factor of primary production in inland water bodies. Measured in milligrams of phosphate per litre of water sample.

Shadow Price: Price 'adjusted' to eliminate any distortions caused by policies or market imperfections so as to reflect true willingness to pay.

Social Cost: The total cost to society of an economic activity.

Total Dissolved Solids: TDS is the amount of solids present in the water sample in dissolved form. This is the absorbable form of compounds to all living forms. Measured in milligrams per litre of sample. Drinking water limits of TDS is 1000 mg/

Total Economic Valuation: Assessment of the total economic contributions, or net benefits, to society of the wetland system (e.g., for national income accounting or to determine its worth as a protected area).

Total Hardness: It is the measure of salts like calcium bi-carbonate, carbonate and magnesium sulphate dissolved in water hardness has adverse effect on domestic use of water.. High hardness brings scales in the boilers. Unit of total hardness is mg/l. Maximum permissible limit of hardness for drinking water is 500mg/l

Turbidity: It is the measure of colloidal suspended matter in the water which hinder/ reflect the light. Turbidity higher than 5 units affect the clarity of water & make it unacceptable for drinking.

Valuation: Quantification of the values of a good or service.

Value: The worth of good or service, generally measured in terms of what we are willing to pay for it, less what it costs to supply it.

Weeds: They are the unwanted plants growing in a water body. They prevent light penetration and makes breeding ground for vectors like mosquitoes. Decayed plant parts gives more BOD to the water. They are the indicators of high nutrient content of the water.

Wetland Function: Processes among and within the various biological, chemical and physical components of a wetland, such as nutrient cycling biological productivity and groundwater recharge.

Willingness to Pay: The amount that someone is prepared to pay to purchase a good or use of a service regardless of whether there is a prevailing market price or the good or service is available free of charge.

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ANNEXURE I

Ward-wise Population of Bhopal City

Ward No.	Name of Ward	Population (1991)	% of Total Population	No. of Samples
1*	Mahatma Gandhi	16009	1.506	23
2*	CTO ward	4856	0.456	6
3*	Hemukalani	15470	1.455	22
4*	Sadhu Waswani	15866	1.492	22
5*	Koh-e-Fiza	15267	1.436	22
6*	Noor Mahal	16304	1.534	23
7*	Malipur	16210	1.525	23
8	Bag Munshi Hussain Khan	16290	1.532	23
9*	Idgah Hills	16087	1.513	23
10	Babu Jag Jeeyan	16322	1.535	24
11*	Gufa Mandir	16958	1.595	25
12	Geetanjali	16710	1.572	25
13	Shahjahanabad	16547	1.556	23
14	Congress Nagar	16497	1.552	23
15	Motilal nehru	14087	1.325	21
16	J.P.Nagar	15500	1.458	24
17	Ibrahim Ganj	15545	1.462	24
18	Ram Mandir	14520	1.366	22
19	Mangalwara	14357	1.350	22
20	Lal Bahabur Shastri	14975	1.409	23
21	Mahaveer ward	15163	1.426	23
22	Jain Mandir	14401	1.355	22
23*	Moti masjid	15616	1.469	24
24	Islampura	14825	1.394	22
25*	Bhoipura	13879	1.305	22
26*	Ram Kamalapati	14701	1.383	22
27*	Vivekanand	14499	1.364	22
28*	Ambedkar	17625	1.658	25
29	Tulsi ward	16471	1.549	24
30	Panchsheel Nagar	16486	1.551	24
31	Maulana Azad	17675	1.663	26
32	Shivaji Nagar	16212	1.525	24

33	T.T.Nagar	16267	1.530	24
34*	Jawahar Lal Nehru	16728	1.573	24
35	P Madan Mohan Malviya	16874	1.587	24
36*	Ravindra nath Tagore	17735	1.668	26
37*	Jehangirabad	17152	1.613	25
38*	Barkheri	15960	1.501	22
39	Chand Barh	15,568	1.464	21
40	Kapda Mill	14706	1.383	18
41	Bag Umrao Dulha	15159	1.426	22
42	Aish Bagh	15200	1.430	22
43	Maharani Laxhmi Bai	16028	1.508	23
44	Jinsi Ward	14172	1.333	18
45	Maida Mill	17186	1.617	25
46	Netaji Subhash Chandra	15617	1.469	21
47	Maharana Pratap	17234	1.621	25
48	Ravi Shankar	17257	1.623	25
49	Dr. Rajendra Prasad	17721	1.667	26
50	Indira Gandhi	16202	1.524	24
51	Shahpura	16479	1.550	21
52	Asha Niketan	17721	1.667	25
53	Barkatullah	17486	1.645	25
54	Barkhera Pathani	16687	1.570	23
55	Saket-Shakti	15394	1.448	22
56	Kasturba	15000	1.411	20
57	Anna Nagar	16381	1.541	22
58	Barkhera, BHEL	17025	1.601	24
59	Govindpura	15409	1.449	21
60	Piplani	17551	1.651	25
61	Gautam Buddha	16801	1.580	23
62	Sonagiri	17489	1.645	25
63	Indrapuri	16758	1.576	23
64	Guru Nanak	15593	1.467	21
65	Rajeev Ward	17692	1.664705	25
66	Nabi bagh	15036	1.414792	21
Total		1,062,771		1504

*** Wards draining into the lakes**

Source : Bhopal Municipal Corporation

ANNEXURE II

CONTINGENT VALUATION QUESTIONNAIRE FOR BHOJ WETLAND

Indian Institute of Forest Management,
Nehru Nagar,
Bhopal 462 003

TO BE FILLED OUT BY THE INTERVIEWER
FILL IN BEFORE INTERVIEW

Respondent's name:
Mr. / Mrs. / Ms / _____

Address:

_____

_____

_____

Telephone: _____

3. Date of Interview: _____

4. Start time of the Interview: _____
FILL IN AFTER INTERVIEW
5. End Time of the Interview: _____

6. Length of Interview: _____

7. Name of the Interviewer: _____

INTRODUCTION

Interviewer:
Good Morning (evening), my name is _____(first name and surname), and I am working on behalf of the Indian Institute of Forest Management. We are carrying out a survey for which we need to ask you a few questions. It will take around half an hour. Or, if you prefer, I could come back later.
IF ASKED TO COME BACK LATER, ASK FOR A SPECIFIC TIME (AND DATE)
IF AGREES TO BE INTERVIEWED IMMEDIATELY, PROCEED TO (2)

Credentials:
SHOW 1. Letter from Director, IIFM
AND 2. The Official Enumerator Badge

Let me begin by telling you a few things about this survey. As you may know the Upper Lake and the Lower Lake together constitute what is known as the Bhoj Wetland. These lakes are an important part of the city of Bhopal. Steps are being taken to maintain the wetland but these are costing the government a lot of money. The results of this survey will go towards helping the state government to make better decisions about whether these steps to maintain the lake are worthwhile to citizens like you.

Firstly, let me tell you that this interview is to do with your attitudes and opinions. There are no right or wrong answers. The answers that you provide may be used by policy makers in their decisions.

How would you rank the following problems that the country is facing right now according to their order of importance to you as a person:

1 - most important
2 - very important
3 - important
4 - somewhat important
5 - Least important

Problem	Ranking
a) Corruption	
b) Foreign infiltration	
c) Pollution/Environmental Degradation	
d) Lack of a stable government	
e) Economic Issues	

How would you rank the following environmental problems:

1 - most important
2 - very important
3 - important
4 - somewhat important
5 - Least important

Problem	Ranking
Deforestation	
Urban Waste / Solid waste pollution	
Noise pollution	
Vehicular pollution	
Industrial pollution	

3. What are your sources of drinking water?

Municipal supply (taps)
Tube well
Tankers
other source:_____

4. Do you use any of the following appliances / techniques for water purification purposes?

Aquaguard
Zero B
Ordinary Filter
Chlorine/Alum
Boil Water
None

5. Please rank the following statement:

“Important wetlands like the Bhoj Wetland require special conservation measures”

Strongly agree
Agree

Neutral
Disagree
Strongly disagree

6. You may be aware that the Bhoj Wetland provides a number of services to the citizens of this city. A few of them are listed below. Kindly rank them according to their importance in your opinion.

1 - most important
2 - very important
3 - important
4 - somewhat important
5 - Least important

Services	Ranking
Drinking Water	
Stability of microclimate	
Employment to fishermen, boatmen, *singhara* cultivators and *dhobis*	
Recreation and tourism because of boating and Van Vihar	

7. Do you ever visit the Upper Lake for recreational purposes like boating etc.?
Yes
No

8. Do you ever visit the Lower Lake for recreational purposes like boating etc.?
Yes
No

IF NO SKIP TO QUESTION 10.

9. How often do you go to the Lakes / Van Vihar?
Every week
Once in a fortnight
Once in a month
Once in two - six months
Once in seven - twelve months

10. To what extent is the Upper Lake polluted in your opinion?
a) Marginally
b) Moderately
c) Highly
d) Not at all

11. To what extent is the Lower Lake polluted in your opinion?
a) Marginally
b) Moderately
c) Highly
d) Not at all

12. How would you rank the various threats to the lakes in order of importance?

1 - most important
2 - very important
3 - important
4 - somewhat important
5 - Least important

	Problem	Ranking
a.	Siltation	
b.	Solid waste pollutants like polythenes, etc.	

c.	Sewage	
d.	Washermen	
e.	*Trapa* cultivators	
f.	Encroachment	
g.	Increasing population	
h.	Weeds and eutrophication	
i.	Boating	
j.	Agricultural waste	
k.	Idol immersion	
l.	Hospital waste like bandages, waste medicines, etc.	
m.	Others, please specify	

VALUATION

B. SHOW THE PHOTOGRAPHS OF THE POLLUTED AND RESTORED WETLAND AND THE STRUCTURE AND FUNCTIONS OF THE PROPOSED BODY

It is being tried to place a money value on services that you derive from the Lakes. You derive a number of benefits from this Wetland like recreational opportunities and microclimatic stabilisation. Suppose, an independent body was formulated by the government to maintain the lakes in the future for recreational activities and it would look after the Upper and Lower Lakes, maintaining and developing the recreational opportunities that would be made available to the people of Bhopal. This body would develop and maintain parks by the wetland, promote adventure boating, and other forms of ecotourism, fishing sports and other such activities. It would help to maintain the aesthetic beauty of the wetland as well. This kind of a body would require funds for operating. Suppose that this body would operate only on the funds collected through voluntary contributions and not through any government aid, we would like to know about your contribution to such a body? The persons contributing to this fund would get a privilege membership to the society whereby they could enjoy the various activities promoted by the society on nominal payment of ticket charges.

13. Assuming that such a body was formed and would work perfectly as specified, how much money would you (and your family) pay voluntarily, every year, to enjoy the improved recreational and aesthetic benefits of the Bhoj Wetland?

None - GO TO QUESTION 14

Initial Amount: Rs _____

ACCORDING TO THE BAND WITHIN WHICH THIS AMOUNT FALLS, SELECT THE NEXT AMOUNT AND ASK THE FOLLOW - UP QUESTION

A.	1 - 250	Ask for Rs 300
B.	251 - 500	Ask for Rs 750
C.	501 - 1000	Ask for Rs 1500
D.	1001 - 2000	Ask for Rs 3000
E.	More than 2000	Ask for Rs 5000

FOLLOW UP QUESTION: Since you are probably doing such a valuation exercise for the first time, let me try and ask you if this is definitely the value that you would place on the improved services that you would receive from the Bhoj Wetland

For instance, would you pay Rs _____, (value from the list given above corresponding to the band containing the initial bid) per year, on behalf of yourself and your family, in order to enjoy an improved Bhoj Wetland?

YES

NO

ENTER THIS AMOUNT AS **NEXT VALUE STATED**

NEXT VALUE STATED: Rs _____

You have a limited income and in that case do you think that it will be possible for you to pay the amount that you have stated. If you want you can still adjust the amount

_

Suppose the government imposes a compulsory tax upon all the citizens of the city, whereby, the collections from this tax would entirely go towards maintaining the Wetland and providing the activities listed above with no special membership benefits, through the formation of a similar body. In this case how much would

Should there be a gate fee at the entrance of the parks that are created?

YES

NO

IF NO SKIP TO QUESTION 20

If so what should the amount per adult be fixed at?

Re 1 – Rs 5

Rs 6 – Rs 10

Rs 10 – Rs 20

Rs 21 – Rs 50

Above Rs 50

People who say no usually have a reason for it. Could you please specify why you are not willing to pay for the benefits of the wetland?

a) The government should pay YES/NO
b) The user should pay YES/NO
c) I cannot afford to pay YES/NO
d) The Wetland is not important to me YES/NO
e) Other reasons:_____

Suppose that you were to buy a plot / piece of property within the city. What importance would you give to the following factors?

1 - most important
2 - very important
3 - important
4 - somewhat important
5 - Least important

Variable	Rank
Proximity to a market place	
Proximity to place of work	
Proximity to major highways	
Proximity to children's school	
Proximity to the lake	
Proximity to a hospital / nursing home	
Safe neighbourhood as concerned to crime rate	
Quality of construction	
Age of house	

Housing Density	
General Air Pollution Levels	
Level of Noise Pollution	
Proximity to a park	
Availability of household help	
Availability of regular drinking water	

SOCIO - ECONOMIC CHARACTERISTICS

21. Occupation:

1. Private Sector Employee _____
2. Government Employee _____
3. Self Employed _____
4. Other _____

22. Number of Household Members above the age of 18: _____

23. Number of Household Members below the age of 18: _____

24. Formal education level of the head of the household / respondent

A. Below Class XII
B. Upto Class XII
C. Undergraduate (B.A./ B.Com/B.Sc)
D. Postgraduate (M.A. / M. Com / M.Sc.)
E. Professional Qualifications (B.E. / B. Tech. / M.B.A. / M.B.B.S.)
F. Other _____

25. Please tell me the category which includes your (and your household's) total annual gross income from all sources for the last year (i.e. 1998 - 99):

A. < Rs 25,000
B. Rs 25,000 - Rs 50, 000
C. Rs 50,000 - Rs 1 lakh
D. Rs 1 lakh to Rs 2 lakhs
E. Rs 2 lakhs to Rs 3 lakhs
F. Rs 3 lakhs to Rs 5 lakhs
G. Rs 5 lakhs and above.

26. Since when have you been staying in Bhopal?

Less than 1 year
1 – 5 years
5 – 10 years
10 – 20 years
20 and more

Concluding the interview: Thank you very much for your time. But before leaving I would like you to please answer the following questions as well.

GIVE THE RESPONDENT THE NEXT PART OF THE QUESTIONNAIRE

RESPONDENT EVALUATION

27. How well did the interviewer explain the context of the questions and the questions themselves?

a) Very well
b) Well
c) Not very well
d) Badly

Please tick the relevant option

28. Do you believe that your answers will influence the decision by the government to create a body for improving the recreational facilities of the Upper and Lower Lakes?
a) YES
b) NO
c) PERHAPS
29. Do you believe that you may be asked to pay for improvements in the Bhoj Wetland?
a) YES
b) NO
c) PERHAPS

ENUMERATOR EVALUATION AND DECLARATION

COMPLETE THESE QUESTIONS AS SOON AS POSSIBLE AFTER THE INTERVIEW

These questions are only concerned with how the respondent answered the questions on valuations.

30. Irrespective of whether or not the respondent answered the questions on valuation, in your judgement, how well did the respondent understand what he or she was asked to do in these questions?

1. Understood completely
2. Understood most of them
3. Understood somewhat
4. Did not understand at all
5. Other (specify)

_____
_____
_____
_____

31. Which of the following descriptions best describes the degree of effort the respondent made to arrive at a value for the stated uses

1. Gave the questions prolonged consideration
2. Gave the questions careful consideration, but the effort was not prolonged
3. Gave the questions very little consideration
4. Other (specify)

_____
_____
_____
_____

FILL IN THE DETAILS ON THE TOP SHEET REGARDING TIME AND LENGTH OF THE INTERVIEW

DECLARATION BY THE ENUMERATOR

I hereby certify that this is an honest interview taken in accordance with my instructions.

_____ _____

Name of the Enumerator Signature of the Enumerator Date

ANNEXURE III

One day Workshop on Sustainable Use of The Bhoj Wetland: Stakeholders' Perspective, 13th March, 2000

List of Participants of the workshop:

Mrs Vibha Patel, Mayor, Bhopal

Dr. Satyanand Mishra, Principal Secretary, Housing and Environment Department, Govt of M.P.

Dr. Ram Prasad, Director, IIFM

Dr. A. J. James, Environmental Consultant, New Delhi

Dr. Sanjeev Sachdeva, Senior Research Officer, Bhoj Wetland Project

Dr. Balmukund Bharati, Sahyog

Dr. R.P. Upadhayay, Kshetriya Vikas Evam Jan Kalyan Samiti

Dr. J.S. Vashir, Swasthya Sampada

Dr. Vipin Vyas, Department of Limnology, Barkatullah University, Bhopal

Mr. Abdul Jabbar, Gas Peedit Mahila Morcha

Mr. Satinath Sarangi, Sadbhavna Trust

Ms Nishi Nariyani , M.P. Council Of Science and Technology

Corporators of various Municipal Wards

Representatives from Fishermen, Washermen, Boatmen communities

Project Team Members of IIFM

Workshop Proceedings:

The participants were introduced with the objectives and methodology of the project and how different valuation techniques like the Contingent Valuation Method Hedonic Pricing, market analysis shall be used to arrive at the economic value of the wetland. It was also mentioned that the co-operation of all the stakeholders in the Wetland will be required for effective completion of the project .

This was followed by division of the participants into three groups and taking up of one issue by each. The **sticky cloth and paper** technique was used to facilitate the discussions. The groups dealt with three important topics like sewage and waste disposal, fishing and washing activities and recreational activities. The outcome of the group discussions and the response of the concerned departments who replied to the queries, problems and alternatives suggested are listed in the table given

GROUP 1 – SEWAGE AND WASTE DISPOSAL

EPCO ACTION	PROBLEMS FACED OR REMAINING	ALTERNATIVES & ADDITIONAL ACTION NEEDED	INFORMATION GAP	RESPONSE OF THE CONCERNED DEPTT.
Deweeding	Unhealthy Environment	Removed weeds to be converted into compost / manure		
Relocating sites of Idol immersions	Not practical	Small, metallic idols can be encouraged		
Sewerage system in all lake peripheral wards and its treatment	Waste disposal from slum areas where no sewage line exists	Treatment of sewage water and putting the water back into the lake to maintain water level Use of sewage water in irrigation		Non-traditional sewage plants, based upon the famous Calcutta system are being set up No response to problem of waste disposal in slums
Solid Waste Management, Waste Collection Bins and Municipal System for collection and disposal of waste in open land	Vegetable waste disposal from weekly market areas Cost & time required for collection of waste vis a vis creation of unhygienic conditions	Ask for advice from MJS, Lucknow, an NGO, which is successfully managing solid waste collection and treatment (organic compost through vermiculture) Dumping of solid waste to alternate site vis a vis alternate use of waste by processing		Such action is welcome/ will be encouraged
Removal of slums from the fringe area and link road construction		No alternative		Policing systems are not enough to ensure total removal

GROUP 2 – FISHING AND WASHING ACTIVITIES

EPCO ACTION	PROBLEMS	ALTERNATIVES	INFORMATION GAPS	RESPONSE OF THE CONCERENED DEPTT.
Plantation	Litter fall Organic Matter / Bird Droppings More Pollution Skin Problems	Plantations should be carried out away from the shore line		Plantation near the shore line is no longer being carried out but in the buffer zone
Deweeding	Nets are damaged Other weeds come up	Navigation routes of motor boats used in deweeding operations should be demarcated		To be pointed out to the BWL Project authorities
Fencing & Road	No place for fishing boats to land No access to lake for fishermen Water hyacinth	Gaps in the fencing should be provided to give space to the boats for landing		Van Vihar National Park is a notified area and so nothing can be done about it
Grass Carp	No information given to the fishermen about the stocking rate Fingerlings are flushed out from the spill way when the Bhadbhada gates are opened	Land should be provided in the vicinity of the lake to stock seed during rains Make Bhadbhada sluice gates an overflow system (as existed previously)		Project is already done with and check with PWD about the previous type of dam at Bhadbhada
Desilting	No information No idea about its impacts	Fishermen should be informed before the operation		Pamphlets to be distributed about this. Desilting to be done only in areas where there are no fishing activities
Removal of Dhobi Ghats	Two ghats belonging to dhobis, the one with the larger communtiy is consulted and not theirs Alternative space is insufficient for drying washed clothes	Adequate water for washing and drinking and sufficient space for drying clothes should be provided		Area has been chosen by BMC and has been found to be the least unsuitable. Community involvement is to be encouraged

GROUP 3 – RECREATIONAL ACTIVITIES

EPCO ACTION	PROBLEMS	ALTERNATIVES	INFORMATION GAPS	RESPONSE OF THE CONCERNED DEPARTMENT
Retghat Lalghati Road	Additional Lead & SPM going into the Lake Not acting as the proposed buffer between population and lake Solid waste likely to be thrown into lake from road side Building activities continue south of the road near Khanugaon	Chain Link fence to stop waste? Environmental Information Awareness Campaigns? Effective Policing? Close Road?	Scientific testing of impact needed	People look for aesthetic utility from the lake and not just its existence
Chain Link Fencing and Social Forestry	People in *jhuggi jhopris* breaking fence for access to lake for water, sanitation and livelihood needs	Rehabilitate(relocate) those *jhuggi jhopris* which haven't been shifted elsewhere Reforest the area with community participation	EPCO provisions for rehabilitation Who will look after the newly planted trees?	Policing not efficient and enough anyway
Deweeding – Water hyacinth	Complete removal upsets ecosystem How to harvest optimal amounts in future? Who? Problem with carp introduction?	Limnology Department and local fishermen to estimate optimal harvest High Powered multi disciplinary expert group (including ITK) to	How much of water hyacinth is useful? Has	

		look into issues Same for *Ipomoea* and other aquatic grasses Collaborate with other Ramsar Lake actors and conventions	EPCO done any studies	
Inaction against Ranjit Hotel Inaction against construction of residential complexes Jehanuma proposal – all 3 within 50 m buffer zone	Precedent for others Possible contamination despite cleaning systems	Since these are illegal constructions , the State Government can demolish these structures. A legal precedent is the demolition of Kamal Nath's hotel in H.P. for violating environmental norms. This will help enforce existing laws.	Has EPCO made a formal representation against Hotel Ranjit ?	Pressure from the public needs to be put so that more such hotels cannot come up
Discouraging Boating and moved to spill channel	Loss of revenue to M.P. Tourism	No alternative; but apply ban uniformly		Yes, plans to shift the boating are on. Sports cannot be banned since they do not contribute to the pollution as such
Floating fountains	Not effective with regard to sewage control and uneconomical Who will bear the operation and management costs after the BWL project is over? Dirty water being sprayed on people on road	Discontinue if not possible to maintain. Concentrate instead on sewage flowing into lake.		

ANNEXURE IV

Maintenance of Works (Annual Cost)

(i) Deweeding @ 2.5% of the work cost(Rs 1264 lacs) = Rs 31,60,000

(ii) Desilting @ 0.05% of the works cost (4200 lacs) = Rs 2,10,000

(iii) Check dams, silt traps, cascades
@ 2% of costs (Rs 100 lacs) = Rs 2,00,000

(iv) Afforestation @ 2.5% of the works cost (Rs 800 lacs) = Rs 20,00,000

(v) Floating fountain @ 5% of the work cost (Rs 500 lacs) = Rs 25,00,000

Total = Rs 80,70,000

Source: Bhoj Wetland Project Office

ANNEXURE V

FUNCTIONS AND ACTIVITIES OF THE BHOJ WETLAND MAINTENANCE SOCIETY

- **Maintain Water Quality And Improve Lake Management**
- **Build Parks And Maintain Them**
- **Better Boating Facilities With Introduction Of Water And Adventure Sports**
- **Encourage Sport Fishing Using Rods**
- **Hold Summer Camps For Children And Youth For Water Related Recreational Activities**
- **Promote Ecotourism By Encouraging Visitors To Learn About Lake Ecosystem And Biodiversity and How To Decrease Water Pollution By Regulating Use Of Polythenes, Etc. And Water Consumption**
- **Develop View Points With Sitting And Refreshment Arrangements**
- **Introduction Of Dal Lake Type *Shikaras***
- **Generate Awareness For Clean Lakes By Holding Annual Lake Festival, Distributing Souveniers, Declare Lakes As City's Heritage, Etc.**

LIST OF POTENTIAL BENEFITS FROM THE BHOJ WETLAND FROM THE STAKE HOLDER'S PERSPECTIVE

Direct Benefits:

1. Water supply to the city – Half the city's water is supplied from the upper lake.
2. Commercial fishery – Major source of supply of fresh water fish for the city's fish loving population
3. Recreation – Boating facilities include speed/motor boats, row boats and paddle boats. Favourite haunt of the city's fun loving population.
4. *Trapa* and lotus cultivation – Source of the city's supply of the same but also a major menace to the lake waters.
5. Sewage Disposal - The lower lake especially serves as a dump not only for the sewage wastes but also for the solid wastes. Many households open directly onto the lake and the garbage is dumped directly into the lake water.
6. Van Vihar National Park – This encloses a portion of the lake and these waters support the Van Vihar by providing not only water but also aesthetic beauty and more important a home to many species of migratory birds that arrive in the winters.

Indirect Benefits:

1. Ground Water Recharge – This is a very important function of the Bhoj Wetland for which it had initially been constructed in the eleventh century.
2. Nutrient Retention – The lakes have a very large catchment area and along with the water that is recharged a large amount of silt also comes into the lakes. The nutrient content in the lake waters thus increases and this serves as a good medium for the phyto-planktons and zoo-planktons and other macrophytic life forms in the lake waters.
3. Micro-climatic stabilisation – The lakes provide a very congenial environmental cooling effect in summers and a warming one during winters due to the large expanse of water surface. This is a very important function of the lakes.
4. Bio-diversity maintenance – This is another major function of the lake whereby the fresh water bio-diversity is maintained and also that in the Van Vihar.

LIST OF STAKEHOLDERS IN THE BHOJ WETLAND

1. The general population of the city – The large part of the benefits of the Bhoj Wetland accrue to the general population including both direct and indirect benefits.
2. Fishermen / Boatmen / *Trapa* cultivators / Washermen (*Dhobis)* – These people are dependant upon the Bhoj Wetland for their daily livelihood. The lakes form an integral part of their livelihood earning mechanisms.
3. Farmers – These people get the benefits of ground water recharging by the lake and so save a lot in costs.
4. State Government – It is a major stakeholder in the Bhoj Wetland since it is responsible for not only its management but is also the major policy maker as far as the Wetland is concerned.
5. Lake Front Property Owners – These are mainly the large hotels like the Jehanuma Palace, Lake View Ashoka, and the residential houses on Shyamla Hills and Koh-e-fiza. This land is considered to be prime property because of its proximity to the lake and the view that it provides.
6. National Park Authorities / Management – These are also a major stakeholder since the existence of the National Park is greatly dependant upon the Bhoj Wetland. There are conflicts because of the commercialisation of the lake by the State Government and the needs of the National Park.
7. Visitors – Though these are mainly part of the general population of Bhopal itself, (since the lake is a major attraction for the locals and not outsiders), they are taken as a separate sub-group since these people could give a more precise estimate of the value of the lake to him rather than an individual who has not visited the lake since a long time and has no intention of doing so either.